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SECTION 4

TESTING ARRANGEMENTS

Recommendation Q.327

4.1 GENERAL ARRANGEMENTS

The guiding principles for the maintenance of automatic circuits as covered in Recommendations M.700 to M.734 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 Before a circuit equipment is taken for test, the circuit will be withdrawn from service at both international exchanges;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 ± | 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 ± | .2 dB;

c) signal durations should be long enough so that the signals can be recognized. See Recommendation Q.313, § 2.3.3.

2) *Register signal generator characteristics as follows:*

a) signal frequencies should be within ± | .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 ± | .2 dB;

c) signal durations and intervals between signals shall be within the limits given in the specification in Recommendation Q.322, § 3.3.4, for normal operate values and in Recommendation Q.323, § 3.4.1 *d)* , for test operate values.

4.5.3 *Signal-measuring equipment*

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

1) *Line signal measuring equipment characteristics as follows:*

a) signal frequency between the extreme limits given in the specification should be measured with an accuracy of ± | Hz;

b) level of the signal frequency measured over the range given in the specification should be measured with an accuracy of ± | .2 dB;

c) signal durations, and other significant time intervals as given in the specification should be measured with an accuracy of ± | ms or ± | % 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 ± | Hz;

b) level of the signal frequency or frequencies over the range given in the specification should be measured with an accuracy of ± | .2 dB;

c) signal duration and intervals between signals as given in the specification should be measured with an accuracy of ± | ms.

3) In regard to measuring time intervals a recorder having a minimum of two input channels may be useful. The recorder characteristic should conform with the accuracy requirements quoted in 1) and 2) above and be easily connected to the circuit under test. The recorder input characteristic should be such as to have a negligible effect on circuit performance.

ANNEX A TO THE SPECIFICATIONS OF SIGNALLING SYSTEM R1

SIGNAL SEQUENCES

Tableau [A-1], p.5

Tableau [1-A-1], p.6

MONTAGE: PAGE 26 = PAGE BLANCHE

PART II

Recommendation Q.332

INTERWORKING OF SIGNALLING SYSTEM R1

WITH OTHER STANDARDIZED SYSTEMS

MONTAGE: PAGE 28 = PAGE BLANCHE

Recommendation Q.332

5. INTERWORKING

5.1 *General*

System R1 is capable of interworking with any of the CCITT standardized signalling systems.

Specifications on interworking of System R1 with other CCITT signalling systems are not yet available.

Typical information is found in Recommendation Q.180 of Fascicle VI.2.

MONTAGE: PAGE 30 = PAGE BLANCHE

PART III

Recommendations Q.400 to Q.490

SPECIFICATIONS OF SIGNALLING SYSTEM R2

MONTAGE: PAGE 32 = PAGE BLANCHE

SIGNALLING SYSTEM R 2

INTRODUCTION

General

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

System R2 is specified for one-way operation on analogue and digital transmission systems and for both-way operation on digital transmission systems. Distinction is made between line signalling (supervisory signals) and interregister signalling (call set-up control signals). Versions of line signalling are specified for use on 4-wire carrier or PCM circuits. Nevertheless, the interregister signalling specified can also be used on 2-wire circuits. System R2 is suitable for use on satellite links and 3 kHz spaced carrier circuits. It is not designed for use on transmission systems with speech interpolation but it may be used on digital transmission systems with speech interpolation as long as transparency for pulsed interregister signals is guaranteed.

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

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

Line signalling

The following versions of line signalling are specified:

— line signalling for carrier systems called the analogue version;

— line signalling for PCM systems called the digital version.

Since multifrequency signalling permits exchange of a large amount of information between registers, the quantity of information that has to be transmitted in the form of line signals is small. The versions of line signalling for System R2 have been designed accordingly. The analogue line signalling version standardized originally for use on international circuits is also suitable for national working. An analogue (in-band) line signalling version is only described for the specific use on 3 kHz spaced carrier circuits of international submarine cables.

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

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

The analogue version and the digital version of the line signalling can be converted to each other by a transmultiplexer or other conversion equipment. Such equipment forms a conversion point between analogue (FDM) transmission on one hand and digital (PCM) transmission on the other hand. The System R2 line signalling, however, must be treated separately because for both transmission systems different line signalling versions are specified. Although both versions are described in some detail, a description of the actual conversion is given in Recommendation Q.430. Although these versions do not include a forward-transfer signal, forward-transfer signalling may be introduced for international working by bilateral agreement.

Interregister signalling

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

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

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

Figure 1, p.

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

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

In the case of satellite working, the register at the incoming end of the satellite link must act as an outgoing R2 register (see also Recommendation Q.7).

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

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

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

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

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

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

— capability of transferring address information for automatic, semi-automatic and maintenance calls;

— indicators in order to identify transit and maintenance (test) calls;

— language digits or discriminating digit(s) for international calls;

— transfer of the next digit or repetition of the last but one, the last but two, or the last but three digit on request by the register at the incoming end;

— forward and backward signals for control of echo suppressors;

— information concerning the nature and the origin of the call (calling party's category) can be transferred to the register at the incoming end, i.e. whether national or international, whether from an operator or from a subscriber, whether from data-transmission, maintenance or other equipment, etc.;

— information concerning the nature of the circuit can be requested by the register at the incoming end, i.e. whether a satellite link is already included or not;

— information on congestion, unallocated number and on the condition of the called subscriber's line can be transferred to the outgoing register, i.e. whether free, busy or out of service, etc.;

— a restricted number of signals left to the discretion of Administrations for allocation of national meanings.

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

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

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

SECTION 1

DEFINITIONS AND FUNCTIONS OF SIGNALS

Recommendation Q.400

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 the idle state to seized state. At the incoming exchange it causes the association of equipment capable of receiving register signals.

1.1.2 **clear-forward signal**

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

The signal is sent when:

a) in semi-automatic working the operator of the outgoing international exchange takes the plug out or performs an equivalent operation;

b) in automatic working, the calling subscriber clears or performs an equivalent operation.

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

1.1.3 **forward-transfer signal**

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

1.2 BACKWARD LINE SIGNALS

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

1.2.1 **seizing-acknowledgement signal**

A signal sent to the outgoing exchange to indicate the transition of the equipment at the incoming end from the idle state to seized state. Recognition of the seizing acknowledgement signal at the outgoing end causes the state of the circuit to change from seized to seizure acknowledged.

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

1.2.2 **answer signal**

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

In automatic working this signal is used:

— to start metering the charge to the calling subscriber, unless the register signal indicating no charge has been sent previously;

— to start measurement of the call duration for international accounting purposes.

1.2.3 **clear-back signal**

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

1.2.4 **release-guard signal**

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

1.2.5 **blocking signal**

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

1.3
FORWARD REGISTER SIGNALS

1.3.1 **address signal**

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

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

1.3.2 **country-code and echo-suppressor indicators**

Signals indicating:

— whether or not the country-code is included in the address information (international transit or terminal call);

— whether or not an outgoing half-echo suppressor should be inserted in the first international exchange reached;

— whether or not an incoming half-echo suppressor should be inserted (an outgoing half-echo suppressor having already been inserted in the connection).

1.3.3 **language or discriminating digit**

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

— in semi-automatic working, the service language to be used in the incoming international exchange by the incoming, delay and assistance operators when they come in the circuit (language digit);

— the automatic working or any other special characteristic of the call (discriminating digit).

1.3.4 **test call indicator**

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

1.3.5 **nature of circuit indicators**

Signals only sent on request by certain backward signals and using a second meaning of some signals, to indicate whether a satellite link is already included in the connection or not.

1.3.6 **end-of-pulsing signal**

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

1.3.7 **calling party’s category signals**

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

Typical categories are:

— operator capable of sending the forward-transfer signal;

— ordinary subscriber or operator with no forward-transfer facility;

— subscriber with priority;

— data transmission call;

— maintenance call.

1.3.8 *Signals for use on the national network*

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

1.4
BACKWARD REGISTER SIGNALS

1.4.1 *Signals requesting transmission of address signals*

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

— signal requesting the transmission of the address signal following the latest address signal sent;

— signal requesting repetition of the address signal preceding the latest address signal sent (last but one);

— signal requesting the repetition of the last but two address 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 *Signal requesting information about the circuit*

A backward signal is provided to request the nature of the circuit.

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

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

— signal inquiring the calling party’s category;

— signal requesting the repetition of the country-code indicator;

— signal inquiring whether or not incoming half-echo suppressor should be inserted.

1.4.4 *Congestion signals*

Two congestion signals are provided:

— a signal indicating international congestion, i.e. that the call set-up attempt has failed owing to congestion of the group of international circuits, or congestion in the international switching equipment, or to time-out or abnormal release of an incoming R2 register in an international transit exchange;

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

1.4.5 **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.

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

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

— **send special information tone**

a signal sent in the backward direction indicating that the special information tone should be returned to the calling party. This tone indicates that the called number cannot be reached for reasons not covered by other specific signals and that the unavailability is of a long term nature. (See also Recommendation Q.35);

— **subscriber line busy**

a signal indicating that the line or lines connecting the called subscriber to the exchange are busy;

— **unallocated number**

a signal indicating that the number received is not in use (e.g. an unused country code or an unused trunk code or subscriber number that has not been allocated);

— **subscriber line free, charge**

a signal indicating that the called subscriber's line is free and that the call is to be charged on answer;

— **subscriber line free, no charge**

a signal indicating that the called subscriber's line is free and that the call is not to be charged on answer. This signal is used only for calls to special destinations;

— **subscriber line out of order**

a signal indicating that the subscriber's line is out-of-service or faulty.

1.4.7 *Signals for use in the national network*

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

SECTION 2

LINE SIGNALLING, ANALOGUE VERSION

Recommendation Q.411

2.1 LINE SIGNALLING CODE

2.1.1 *General*

The System R2 line signalling, analogue version, is intended for use on carrier circuits. The line signals are transmitted link-by-link. The code for the transmission of line signals is based on the *tone-on-idle* signalling method

employed are equipped in each direction of transmission with a signalling channel outside the speech frequency band. When the circuit is in the idle state, a low-level signalling tone is sent continuously in both directions over the signalling channels. The tone is removed in the forward direction at the moment of seizure and in the backward direction when the called subscriber answers.

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

The signalling system is specified for one-way operation of 4-wire carrier circuits.

2.1.2 *Line conditions*

Tone-on or tone-off denotes a certain line signalling condition. The line thus has two possible conditions in each direction, i.e. a total of four line signalling conditions. Taking into account the time sequence, the circuit may resume one of the six characteristic states shown in Table 1/Q.411.

TABLE [1/Q.411] p.

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

Recommendation Q.412

2.2 CLAUSES FOR EXCHANGE LINE SIGNALLING EQUIPMENT

2.2.1 *Recognition time for transition of signalling condition*

The recognition time t_r for a changed condition (transition from tone-on to tone-off or vice versa) is 40 ± 10 ms | duration that the presence or absence of a direct current signal must have at the output of the signal receiver in order to be recognized as a valid signalling condition by the exchange equipment. Thus the specified value does not include the response time $t_{r\backslash ds}$ of signalling receivers (see Recommendation Q.415). However, it is determined on the assumption that there is interruption control (see Recommendation Q.416).

2.2.2 *States and procedures under normal conditions*

2.2.2.1 *Seizure*

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 *Answering*

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

2.2.2.3 *Clear-back*

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 after it is recognized in this exchange. When another signalling system is used on the preceding link, the

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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.

Originally this value was (20 ± 7) ms. Since there will be no problem in the interworking between equipment having the original recognition time t_r = (20 ± 7) ms, and equipment having the new recognition time t_r = (40 ± 10) ms, existing equipment need not necessarily be changed to the value

t_r = (40 ± 10) ms.

rules for interworking are applicable. The provisions set forth in § 2.2.2.6 below must also be taken into consideration.

2.2.2.4 *Clear-forward procedure*

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

2.2.2.5 *Blocking and Unblocking procedure*

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 the idle state. The circuit may then be seized for a new call.

2.2.2.6 *Release and release-guard sequence*

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

a) *Release prior to answered state*

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

i) the tone in the backward direction is removed;

ii) the release of the switching units is initiated;

iii) the release-guard sequence starts.

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

FIGURE 2/Q.412 p.

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

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

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

b) *Release in answered state*

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

Figure 3/Q.412 p.

c) *Release in clear-back state*

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

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

Figure 5/Q.412 shows the factors involved in calculating the intervals T_1 and T_2.

At the outgoing end when the interval T_1 has elapsed (Figure 5/Q.412, point D) the tone-off condition in the backward direction can be expected and recognized with certainty in all cases mentioned in § 2.2.2.6 above.

Similarly, the interval T_2 preceding the restoring of the tone in the backward direction may be applied in all cases. To avoid false operation in the event of coinciding forward and backward signals or an irregular sequence of signals, the time interval T_2 must also be observed with the release operation [see § 2.2.2.6 b) above].

Figure 4/Q.412, p.11

Figure 5/Q.412, p.12

The minimum value of T_1 is the sum of the maximum values of the times required for the various operations which take place between application of the tone in the forward direction and recognition of the absence of tone in the backward direction.

T_2 delays release of the circuit. It must therefore be as short as possible. However, it must be long enough to ensure recognition of the tone-off condition in the backward direction at the outgoing end when T_1 is at its maximum, even when this condition begins as early as possible.

a) Exclusive terrestrial circuits

The calculation is based on a maximum one-way transmission delay of 30 ms for a circuit. Thus, for circuits on high-velocity transmission systems via terrestrial lines (including submarine cables) the maximum operating range of the specified line signalling system is 4800 km

Values used for the calculation of T_1 and T_2:

$0 < t_p < 30$ ms

$0 < t_o < 30$ ms (see § 2.3.2.4)

30 ms $< t_r < 50$ ms

$0 < t_i < 20$ ms

Calculation of intervals T_1 and T_2:

$T_1 > AC$ $\quad T_1 > 2\,(t_p + t_o)$ max. $+ t_r$ max. $+ t_i$ max.

$T_1 > (2 \times 60 + 50 + 20)$ ms

$T_1 > 190$ ms

Allowing a safety margin of 10 ms and a tolerance of ± | 0%, the specified value of T_1 is (250 ± 50) ms.

$T_2 > BF$ $\quad T_2 > T_1$ max. $+ t_r$ max. $+ t_i$ max. — $2\,(t_p + t_o)$ min. — t_r min. — t_i min.

$T_2 > (300 + 50 + 20 — 0 — 30 — 0)$ ms

$T_2 > 340$ ms

Allowing a safety margin of 20 ms and a tolerance of ± | 0%, the specified value of T_2 is (450 ± 90) ms.

b) Circuits including a satellite link

The calculation is based on the assumption that the complete connection includes two terrestrial sections with a maximum one-way transmission delay of 15 ms each and a satellite section with a one-way transmission delay of (270 ± 20) ms.

Values used for the calculation of T_1 and T_2:

$250 < t_p < 320$ ms

$0 < t_o < 30$ ms (see § 2.3.2.4)

See Recommendation G.114, Fascicle III.1.

$30 < t_r < 50$ ms

$0 < t_i < 20$ ms

Calculation of intervals T_1 and T_2:

$T_1 >$ AC $\quad\quad T_1 > 2\,(t_p + t_o)$ max. $+ t_r$ max. $+ t_i$ max.

$T_1 > (2 \times 350 + 50 + 20)$ ms

$T_1 > 770$ ms

Allowing a safety margin of 30 ms and a tolerance of ± | 0%, the specified value of T_1 is (1000 ± 200) ms.

$T_2 > BF \qquad T_2 > T_1$ max. + t_r max. + t_i max. — 2 ($t_p + t_o$) min. — t_r min. — t_i min.

$T_2 >$ (1200 + 50 + 20 — 2 × 250 — 30 — 0) ms

$T_2 >$ 740 ms

Allowing a safety margin of 60 ms and a tolerance of ± | 0%, the specified value of T_2 is (1000 ± 200) ms.

c) Terrestrial circuits and circuits including a satellite link

The situation in which equipment can serve terrestrial circuits as well as circuits including a satellite link is not to be preferred because for the case of terrestrial circuits the release sequence is unduly prolonged. The calculation is based on the same assumption as in *b)* above, but with a minimum for ($t_p + t_o$) = 0. This does not affect the value of T_1, so also in this situation T_1 = 1000 ± 200 ms.

Values used for the calculation of T_2:

$0 < t_p < 320$ ms

$0 < t_o < 30$ ms (see § 2.3.2.4)

$30 < t_r < 50$ ms

$0 < t_i < 20$ ms

Calculation of interval T_2:

$T_2 > BF \qquad T_2 > T_1$ max. + t_r max. + t_i max. — 2 ($t_p + t_o$) min. — t_r | min. — t_i min.

$T_2 >$ (1200 + 50 + 20 — 0 — 30 — 0) ms

$T_2 >$ 1240 ms

Allowing a safety margin of 40 ms and a tolerance of ± | 0%, the specified value of T_2 is (1600 ± 320) ms.

2.2.3 *Abnormal conditions*

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

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

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

2.2.3.3 If, in the cases given in § 2.2.2.6 a) or c) above, the tone in the backward direction is not removed, the circuit will remain blocked, since it cannot return to the idle state of its own accord. The action to be taken in such cases is described in § 6.6.

2.2.3.4 If after sending of the clear-forward signal the signalling tone in the backward direction is not restored, the circuit stays blocked, as described in section § 2.2.2.5 above. The same occurs when, in the idle state, 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 seizure and connects multifrequency signalling equipment, but no interregister signalling follows.

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

b) When the interruption is shorter than the time-out, restoration of the signalling tone in the forward direction will return the circuit to the idle state in accordance with § 2.2.2.6 a) above.

2.2.4 *Alarms for technical staff*

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

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

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

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

MONTAGE: REC. Q.414 A LA FIN DE CETTE PAGE