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2.3 CLAUSES FOR TRANSMISSION LINE SIGNALLING EQUIPMENT

Recommendation Q.414

2.3.1 SIGNAL SENDER

2.3.1.1 *Signalling frequency*

The nominal value of the signalling frequency is 3825 Hz. Measured at the sending point, the frequency variation from the nominal value must not exceed ± | 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 ± | 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 state, the addition of these tones in moments of low traffic may give rise to the following phenomena on certain transmission systems:

— high peak voltage on the line caused by the signalling tones and involving the possibility of overloading the system;

— intelligible crosstalk due to third-order intermodulation;

— unwanted tones coming from second-order intermodulation products and occurring within sound-programme circuits.

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

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

For further details on the method of random distribution of the phases of frequency 3825 Hz, see: Ekholm, O. and Johannesson, N.O.: ‘‘Loading Effects with Continuous Tone Signalling’’, English edition of *TELE* , No. 2, 1969. For furth-

Other methods may be used provided they give comparable results.

er details on a systematic method of phase distribution, see: Rasch, J. and Kagelmann, H.: ''On Measures for

Reducing Voltage Peaks and Distortion Noise on Carrier Transmission Paths with Single Channel Supervision'', *Nachrichtentechnische Zeitschrift (NTZ)*, 22 (1969), No. 1, pp. 24-31.

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

When a sinewave of frequency *f* is applied to the audio-frequency input of the adjacent channel it produces two signals that appear on the frequency scale of Figure 6/Q.414 as having the frequencies

(4000 + *f*) and (4000 — *f*). The level of the (4000 + *f*) signal, measured at the group distribution frame or at an equivalent point, shall not be higher than —33 dBm0 when the sinewave with frequency *f* is applied to the audio-frequency input of the adjacent channel at a level shown in Figure 6/Q.414 for the frequency of (4000 + *f*). The level of the (4000 — *f*) signal, measured at the group distribution frame or at an equivalent point, shall not be higher than —33 dBm0 when the sinewave with frequency *f* is applied to the audio-frequency input of the adjacent channel at any level below the value shown in Figure 6/Q.414 for the frequency (4000 — *f*).

FIGURE 6/Q.414, p.

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

— the click generator shown in Figure 7/Q.414 is connected to the associated speech channel or to the adjacent speech channel at the very point where this channel is connected to the switching equipment;

— to take the most difficult circumstances possible, the channel level adjusting devices are set to such values encountered in practice which give rise to the worst disturbance;

— gain is introduced in the loop at the group distribution frame or at the equivalent point, so that the receive level at the point in question is +3 dBm0.

FIGURE 7/Q.414, p.

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.415

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* condition 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* condition when the level of the test frequency, at the group distribution frame or at an equivalent point, has dropped to the values shown in Figure 8/Q.415.

FIGURE 8/Q.415, p.

2.3.2.3 *Protection against near-end disturbances*

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

— a sinusoidal signal whose level as a function of the frequency is shown in Figure 9/Q.415,

— a transient signal produced by the click generator (described in § 2.3.1.5 above) applied at the point where the channel is connected to the switching equipment, all level adjusting devices being set to such values encountered in practice which give rise to the worst disturbance.

FIGURE 9/Q.415, p.

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 CCITT having a frequency differing by 140 Hz from the nearest multiple of 4 kHz (see Recommendation M.460).

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

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

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

To ensure proper interruption control, it is essential that the individual transmission or switching equipments should not react to any change of signalling state due to a fault. The action initiated by the interruption control must therefore be completed in less time than the sum of the response time of the signalling receiver and the recognition time for the *tone-off* 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.

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

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

— immediate blocking by intervention of interruption control at the outgoing end;

— blocking on recognition in the backward direction of the *tone-off* condition caused by interruption control intervention at the incoming end.

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

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

Figure 10/Q.416, p.5

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

a) *Circuit in idle state*

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 the idle state of the circuits affected by the fault, by switching sending units at the incoming end to the *tone-on* condition.

b) *Circuit seized prior to answered state*

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 timing arrangement may be the one specified in Recommendation Q.118, § 4.3.3.

Operation i) prevents the transfer of an answer signal while interruption control is in action. If the called subscriber answers before the time out delay mentioned in iii) above has elapsed, then the timer is stopped. For existing equipment this requirement may not apply. If the called subscriber clears while interruption control is active, the part of the connection beyond the faulty circuit must be released immediately.

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 the idle state.

When interruption control reverts to normal before the called subscriber has answered, the call may still mature normally, provided the caller is holding.

If the called subscriber has answered during the time-out delay and the interruption control reverts to normal with both the calling and called subscribers holding, the answer signal is sent immediately.

If at the moment when interruption control reverts to normal the called subscriber has already cleared, operation ii) ensures that in all cases the release-guard sequence takes place as in § 2.2.2.6 a) above (either

immediately if the outgoing exchange has already sent the clear-forward signal or when the caller clears). If, on the other hand, the called subscriber is still holding and the outgoing exchange is already sending the clear-forward signal when interruption control reverts to normal the circuit returns to the idle state at the outgoing end as described in § 2.2.2.6 b) above.

c) *Circuit in answered state*

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 the idle state.

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

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

When the caller has already cleared by the time the interruption control reverts to normal, the release-guard sequence is carried out as in Recommendation Q.412, § 2.2.2.6 b) or c).

d) *Circuit in clear-back state*

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 Recommendation Q.412, § 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* | ondition; 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* | ondition is established in the backward direction and causes the circuit at the outgoing exchange to return to the idle state.

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

a) *Circuit in idle state*

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

b) *Circuit seized but not in answered state (including clear-back)*

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* state 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 state must take place simply on recognition of *tone-on* in the backward direction without necessarily taking into account time-out T1.

c) *Circuit in answered state*

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).]

2.4.3 *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* | hen 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:

$$5 \text{ ms} \; t\downarrow \; t_{r\,min} + 13 \text{ ms}$$

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, $t_{r\,min}$ is the minimum response time of the signalling receiver for a drop in level, taking into account a possible variation of ±| 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.

If the value (40 ± 10) ms is exclusively applied, it is possible to use the minimum value of 30 ms instead of 13 ms for the interruption control device.
The figure of 13 ms in the above formula is derived on the assumption that the output of the interruption control equipment acts upon the input of the device which regulates the recognition time for the *tone-on* and *tone-off* conditions (20 ± 7 ms) , i.e. absence of a direct current signal at this input for a period of up to 13 ms has no relevance.

2.4.3.5 *Response time for rise in level*

Interruption control must revert from the alarm-on to normal in an interval $t\uparrow$ such that:

$$t_{r\,max} - 13 \text{ ms} \; t\uparrow \; 500 \text{ ms}$$

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

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

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

2.4.3.6 *Precautions against noise*

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

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

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

SECTION 3

LINE SIGNALLING, DIGITAL VERSION

Recommendation Q.421

3.1 DIGITAL LINE SIGNALLING CODE

3.1.1 *General*

Primary PCM multiplexes (see Recommendations G.732 and G.734) economically provide more than one signalling channel per speech circuit in each direction of transmission. By making use of the increased signalling capacity, simplification of the outgoing and incoming switching equipment can be achieved since the timing conditions necessary for the System R2 line

signalling, analogue version, are not required. For this reason the digital version of System R2 line signalling is recommended for use on PCM systems in national and international public switched networks and is specified below.

Note — The continuous line signalling scheme specified for FDM systems may also be used on PCM systems by 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 (see Recommendation Q.416) are performed by use of the local alarm facility provided by PCM equipment. This method of line signalling on PCM systems is not recommended for use on international circuits.

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

Under normal conditions:

— The a_f channel identifies the operating condition of the outgoing switching equipment and reflects the condition of the calling subscriber's line.

— The b_f channel provides a means for indicating a failure in the forward direction to the incoming switching equipment.

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

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

The line signals are transmitted link-by-link.

The digital version of System R2 line signalling also specifies a means for appropriate action in the case of faulty transmission conditions on the PCM multiplex, see Recommendation Q.424.

The signalling system is specified for one-way operation, but both-way operation is also possible (see § 3.2.7 below).

3.1.2 *Signalling code*

Table 2/Q.421, shows the signalling code on the PCM line under normal conditions.

H.T. [2/Q.421]

TABLE 2/Q.421

State of the circuit	Signalling code			
	Forward		Backward	a f
Idle/Released	1	0	1	0
Seized	0	0	1	0
Seizure 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
Blocked	1	0	1	1

Table [2/Q.421], p.

Recommendation Q.422

3.2 CLAUSES FOR EXCHANGE LINE SIGNALLING EQUIPMENT

3.2.1 *Recognition of a change of signalling code*

3.2.1.1 *Signalling channel transitions*

The recognition time for a transition from 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 faulty transmission conditions on the PCM multiplex.

The recognition time is defined as the 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 by the exchange equipment.

3.2.1.2 *Change of signalling code*

Recognition of a change of signalling code is thus defined as either of the following:

a) Recognition of a transition detected on one signalling channel with no transition detected on the second signalling channel during the recognition period.

b) Recognition of a transition detected on the second signalling channel during the recognition period already being applied to the first signalling channel. In this case, a change of signalling code is recognized only when both recognition timing periods have elapsed.

3.2.2 *Sent signal time tolerance*

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

3.2.3 *States and procedures under normal conditions* | see Table 2/Q.421)

In the forward direction b_f= 0 is established permanently.

3.2.3.1 *Idle state*

In the idle state the outgoing end sends a_f= 1, b_f= 0. At the incoming end this results in sending a_b = 1, b_b= 0 in the backward direction, provided that the switching equipment at the incoming end of the circuit is idle.

3.2.3.2 *Seizing procedure*

i) *Seizure*

Seizing should occur only if a_b = 1, b_b = 0 is recognized. The outgoing end changes a_f = 1 into a_f = 0. The code a_f = 0, b_f = 0 must be maintained until the seizing acknowledgement signal is recognized. In this way the outgoing switching equipment will only be able to send the clear-forward signal after recognition of the seizing acknowledgement signal.

ii) *Seizure acknowledgement*

After having recognized the seizing signal, the incoming end sends a_b = 1, b_b = 1 as an acknowledgement.

3.2.3.3 *Answering*

The off-hook condition of the called subscriber's line provokes the incoming switching equipment to send a_b = 0, b_b = 1.

The answered state must be established on the preceding link immediately after it is recognized: see also § 3.2.3.6 below.

3.2.3.4 *Clear-back*

The on-hook condition of the called subscriber's line provokes the incoming switching equipment to send a_b = 1, b_b = 1. The clear-back state must be established on the preceding link immediately after it is recognized: see also § 3.2.3.6 below.

3.2.3.5 *Clear-forward procedure*

The cleared condition of the calling subscriber's line or the release of the outgoing switching equipment will normally result in sending a_f = 1, b_f = 0. The outgoing switching equipment will not be restored to the idle state until recognition of the code a_b = 1, b_b = 0: see also §§ 3.2.3.2, 3.2.3.6 and Table 3/Q.422.

3.2.3.6 *Release procedure*

Recognition of the clear-forward signal in the incoming switching equipment initiates the release of the succeeding link even though answering or clearing by the called party has occurred. Upon complete release of the incoming switching equipment, the code a_b = 1, b_b = 0 is established on the circuit. This will cause the circuit to be restored to the idle state and the outgoing switching equipment to become available for another call.

3.2.3.7 *Blocking and unblocking procedure*

Blocking of an idle circuit to new calls at the outgoing end must occur as soon as a_b = 1 and b_b = 1 is recognized: see also Tables 3/Q.422 and 4/Q.422.

The recognition of $a_b = 1$, $b_b = 0$ restores the circuit to the idle state.

3.2.4 *Actions appropriate to various signalling conditions*

In addition to normal conditions described in Table 2/Q.421 other conditions due to faults may be encountered. Tables 3/Q.422 and 4/Q.422 indicate the states appropriate to each signalling code recognized and the actions to be taken at the outgoing and incoming end respectively of a circuit operated with the digital version of System R2 line signalling.

3.2.4.1 *Outgoing end*

H.T. [3/Q.422]

TABLE 3/Q.422

{		Received code a b = 0, b b = 0	a b = 0, b b = 1	a b = 1, b b = 0	a b = 1, b b = 1
Idle/Released	a f = 1, b f = 0	Abnormal, see Note 1	Abnormal, see Note 1	Idle	Blocked
Seized	a f = 0, b f = 0	Abnormal, see Note 2	Abnormal, see Note 2	Seized see Note 2	Seizure acknowledged
Seizure acknowledged	a f = 0, b f = 0	Abnormal, see Note 3	Answered	Abnormal, see Note 3	Seizure acknowledged
Answered	a f = 0, b f = 0	Abnormal, see Note 4	Answered	Abnormal, see Note 4	Clear-back
Clear-back	a f = 0, b f = 0	Abnormal, see Note 4	Answered	Abnormal, see Note 4	Clear-back
Clear-forward	a f = 1, b f = 0	Abnormal, see Note 1	Clear-forward	Released = Idle	Clear-forward
Blocked	a f = 1, b f = 0	Abnormal, see Note 1	Abnormal, see Note 1	Idle	Blocked

Note 1 — In these abnormal conditions the outgoing end must prevent a new seizure of the circuit. A delayed alarm should also be given (see § 3.2.6).

Note 2 — Non-recognition of the seizing acknowledgement signal 100 ms-200 ms after sending the seizing signal on a terrestrial link or 1-2 seconds after sending the seizing signal on a satellite link results in an alarm and either congestion information being sent backward or a repeat attempt being made to set up the call. The outgoing end must prevent a new seizure of the circuit. When the seizing acknowledgement signal is recognized after the time-out period has elapsed, the clear-forward signal must be sent.

Note 3 — Receipt of b b = 0 by the outgoing switching equipment for 1-2 seconds after recognition of the seizing acknowledgement signal and prior to recognition of the answer signal, results in an alarm and either congestion information being sent backward or a repeat attempt being made to set up the call. The outgoing end must prevent new seizures of the circuit. When b b reverts to 1 after the 1-2 seconds timeout period has elapsed, the clear-forward signal must be sent.

Note 4 — In the case of recognition of b b = 0 whilst in the answered or clear-back state, immediate action is not necessary. On receipt of clearing from the preceding link, the clear-forward signal (a f = 1, b f = 0) must not be sent until b b is restored to 1. A delayed alarm should also be given.

Tableau [3/Q.422] + Remarques, p.7

Blanc

3.2.4.2 *Incoming end*

H.T. [4/Q.422]

TABLE 4/Q.422

{		Received code a f = 0, b f = 0	a f = 0, b f = 1	a f = 1, b f = 0	a f = 1, b f
Idle/Released	a b = 1, b b = 0	Seized	Fault see Note 1	Idle	Fault see N
Seizure acknowledged	a b = 1, b b = 1	Seizure acknowledged	Fault See Note 2	Clear- forward	Fault See N
Answered	a b = 0, b b = 1	Answered	Fault see Note 3	Clear- forward	Fault see N
Clear-back	a b = 1, b b = 1	Clear-back	Fault see Note 4	Clear- forward	Fault see N
Clear-forward a b = 0, b b = 1 or a b = 1, b b = 1 }	{ Abnormal seized see Note 7	Fault see Note 7	Clear- forward see Note 7	Fault see Note 7	
Blocked	a b = 1, b b = 1	Abnormal seized see Note 5	Fault see Note 6	Blocked	Fault see No

Note 1 — When in the idle/released state b f changes to 1, b b must be changed to 1.

Note 2 — In these cases a time-out device is started, which after a certain interval clears the connection beyond the faulty circuit: this timing arrangement may be the one specified in Recommendation Q.118, Section 4.3.3. If the answer signal is recognized during the time-out delay, the timer is stopped but the answer signal is not sent on the preceding link until recognition of a f = 0, b f = 0. If the clear-back signal is recognized while the fault persists, the connection beyond the faulty circuit must be released immediately. Additionally, when the incoming register has not started to send the last backward signal, the rapid release procedure described in Note 5 may be used.

Note 3 — In these cases no action is taken until the clear-back signal is recognized, at which stage the connection beyond the faulty circuit is immediately released.

Note 4 — Under these conditions the succeeding link must be released immediately.

Note 5 — In this case immediate action is not necessary. However, rapid release of the circuit should occur if the incoming end simulates answer by sending a b = 0, b b = 1.

Note 6 — Under these conditions no action is taken.

Note 7 — After clear-forward signal is recognized and until the code a b = 1, b b = 0 is sent, all transitions in the forward direction shall be ignored.

Tableau [4/Q.422] + Remarques, p.8

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3.2.5 *Abnormal conditions*

3.2.5.1 *Special release arrangements*

a) If an exchange where an outgoing R2 register is situated recognizes $a_b = 0$, $b_b = 1$ (premature answer) before an address-complete signal A-6 or a Group B signal is received, 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 cases of non-receipt of the answer signal, of delay in clearing by the calling subscriber in automatic working and of non-receipt of the clear-forward signal by the incoming exchange after the clear-back signal has been sent, the provisions of Recommendation Q.118 apply.

3.2.5.2 *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 most likely to occur in this equipment or in the interconnecting cables, result in blocking of the circuit at the outgoing end and in the ultimate clearing of the connection beyond the incoming switching equipment. This can be achieved, as far as possible, by ensuring that a = 1, b = 1 is sent on line upon:

— removal of PCM or switching equipment by maintenance personnel;

— occurrences of abnormal conditions (e.g. open wire, low voltage) in switching equipment.

3.2.6 *Alarms for technical staff*

According to Recommendation Q.117, an alarm must in principle be given to the technical staff upon recognition of abnormal conditions.

Arrangements for these alarms are to be specified by the Administrations.

It is recommended that a delayed alarm be given at the outgoing end for the procedure described under § 3.2.3.7 above (blocking) and for the following reasons:

— when the abnormal conditions covered by Note 1 to Table 3/Q.422 are applicable;

— when the seizing acknowledgement signal is not recognized within the time specified in Note 2 to Table 3/Q.422 after sending the seizing signal;

— when, after recognition of the seizing acknowledgement signal and prior to recognition of the answer signal, $b_b = 0$ is received for 1-2 seconds;

— when the abnormal conditions covered by Note 4 to Table 3/Q.422 are applicable.

It is also recommended that a delayed alarm be given under PCM failure conditions specified in Recommendations G.732 and G.734.

3.2.7 *Both-way working*

System R2 is specified for one-way working, but in principle the line signalling code detailed in Recommendation Q.421 is also suitable for use on both-way circuits. Where Administrations have undertaken, by bilateral agreement, to use both-way working, the clauses and additional specifications for exchange signalling equipment detailed in §§ 3.2.7.1 and 3.2.7.2 below, must be observed.

3.2.7.1 *Procedures under normal conditions*

a) *Double seizure*

Double seizure is assumed if the outgoing equipment is in a seized state and the signalling code $a_b = 0$, $b_b = 0$ is recognized instead of $a_b = 1$, $b_b = 1$ (seizure acknowledgement). 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 seizure the line signalling equipment at both ends must maintain the seized state for a minimum of 100 ms after which the clear-forward signal $a_f = 1$, $b_f = 0$ must be sent.

100 ms after sending the clear-forward signal and on recognition of $a_b = 1$, $b_b = 0$ each end may assume the idle state.

The clear-forward state $a_f = 1$, $b_f = 0$ must be maintained for at least 100 ms to ensure that it is recognized at the other end.

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

b) *Requirements for circuit release*

When a both-way circuit is released, the end which acted as the incoming end must maintain the signalling code $a_b = 1$, $b_b = 0$ for at least 100 ms to ensure that the signal is recognized at the other end after which the circuit becomes idle.

c) *Blocking and unblocking procedure*

When a both-way circuit is blocked manually in its idle state at one end (e.g. end B) the blocking signal must be sent to the other end (A). The circuit must then be kept blocked locally (at end A) against all calls in the A to B traffic direction as long as the blocked state persists in the B to A direction.

In order to avoid permanent blocking, end A should maintain the signalling code a = 1, b = 0 in the direction A to B.

When the blocked state is removed, end B must send the clear-forward signal and must maintain that state for at least 100 ms, before assuming the idle state.

3.2.7.2 *Special arrangement*

The physical realization of signalling equipment terminating a bothway circuit may allow that part of the equipment concerned with outgoing calls to be removed without preventing the remaining equipment from being used for incoming calls. In this case it is only necessary to block the circuit locally against outgoing calls and a blocking signal need not be sent to the other end.

Recommendation Q.424

3.3 PROTECTION AGAINST THE EFFECTS OF FAULTY TRANSMISSION

Faulty transmission conditions in PCM systems can lead to degradation of the speech channels and erroneous signalling. In the case of primary PCM multiplex equipment operating at 2048 kbit/s failures due to loss of frame or multi-frame alignment and/or failure of any other important function results in both PCM terminals going into alarm condition in accordance with Recommendations G.732 and G.734.

Thus both PCM terminals apply the state corresponding to state 1 on the PCM line on each ‘‘receive’’ signalling channel at the interfaces with the switching equipment, as indicated in Table 4 of Recommendation G.732. In this way, the incoming switching equipment receives the equivalent of $a_f = 1$,

$b_f = 1$ on the PCM line and the outgoing switching equipment receives the equivalent of $a_b = 1$, $b_b = 1$.

These characteristics are taken into account in the present specifications (see § 3.2.4) so that:

— at the outgoing end (see Table 3/Q.422) a PCM fault results in a blocked state, seizure acknowledged state or clear-back state. This means that all circuits in the idle state of a faulty PCM multiplex will be blocked against seizure and that seized circuits will go to or remain in the seizure acknowledged or clear-back state;

— at the incoming end (see Table 4/Q.422) a PCM fault can be identified and appropriate actions can be taken.

When the signalling equipment is a part of a digital exchange, it may receive alarm indications in a form other than both signalling bits in state one. The failure may be detected by the signalling equipment or an indication be received from the PCM terminal according to Recommendation G.734.

When the signalling equipment recognizes a failure it must:

— block the detection of signalling transitions to avoid recognition of erroneous signalling codes caused by the failure. This action must be taken as soon as possible and at least within 3 ms as specified in Recommendation G.734 for a PCM terminal,

— react as specified in Tables 3/Q.422 and 4/Q.422 when a signalling code a = 1, b = 1 is detected at the input of signalling equipment situated at the analogue access of a PCM terminal equipment complying with Recommendation G.732.

Recommendation Q.430

3.5 CONVERSION BETWEEN ANALOGUE AND DIGITAL VERSIONS OF SYSTEM R2 LINE SIGNALLING

This Recommendation is applicable to a conversion equipment placed on the circuit between two switching exchanges each using one of the two versions specified for System R2 line signalling. Owing to this particular use, all the specifications for the two versions of the line signalling may not be fully observed. Nevertheless, the diagrams which follow are based on the principles of CCITT Recommendations Q.411, Q.412 and Q.416 for the analogue version and on Recommendations Q.421, Q.422 and Q.424, for the digital version. The only time conditions taken into account in this Recommendation are those set out in the aforementioned Recommendations. The operation of the

interruption control device is also, wherever possible, that specified in Recommendation Q.416. As stated in that Recommendation, the receiver is blocked immediately whenever pilot tone off is detected: since this is a routine operation, it has not been represented explicitly in the diagrams.

The conversion diagrams have been divided into four parts:

— for conversion between the analogue version at the incoming end and the digital version at the outgoing end, into:

— incoming analogue,

— outgoing digital;

— for conversion between the digital version at the incoming end and the analogue version at the outgoing end, into:

— incoming digital,

— outgoing analogue.

It should be noted, however, that this Recommendation can be simplified with respect to alarm processing when the conversion equipment is connected directly at the input or output of a switching exchange; the processes necessary for this application are shown on the diagrams with thickened lines.

1 Drawing conventions

— tone

tf = 1 tone on forward

tf = 0 tone off forward

tb = 1 tone on backward

tb = 0 tone off backward

When recognized

p = 1 pilot tone on

p = 0 pilot tone off

— signalling bits

The conventions are those of Recommendation Q.421.

2 Conversion incoming analogue version to outgoing digital version

2.1 *Incoming analogue*

Figure CCITT-55980, p.

List of timers:

T2: Recommendation Q.412 (§ 2.2.2.7)

T3: 2 to 3 mn Recommendation Q.118 (§ 4.3.3)

In sheets 2 and 4 the diagram for group pilot supervision is given.

In sheets 3 and 5 the diagram for supergroup pilot supervision is given.

Sheet 1 is for group and supergroup pilot supervision.

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FIGURE CCITT-60881 (feuillet 1), p.10

FIGURE CCITT-60891 (feuillet 2), p.11

FIGURE T1115760-88 (feuillet 3), p.

FIGURE CCITT-60901 (feuillet 4), p.12

FIGURE T1115770-88 (feuillet 5), p.

2.2 *Outgoing digital*

Figure CCITT-55990, p.

List of timers:

T6: Recommendation Q.422 (§ 3.2.4.1, Note 2 to Table 3)

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Figure CCITT-60911 (Sheet 1 of 3), p.

Figure CCITT-60920 (Sheet 2 of 3), p.

Figure CCITT-60930 (Sheet 3 of 3), p.

3 Conversion incoming digital version to outgoing analogue version

3.1 *Incoming digital*

Figure CCITT-56000, p.

List of timers:

T3: 2 to 3 mn Recommendation Q.118 (§ 4.3.3)

Blanc

Figure CCITT-60940 (Sheet 1 of 3), p.

Figure CCITT-60950 (Sheet 2 of 3), p.

Figure CCITT-60960 (Sheet 3 of 3), p.

3.2 *Outgoing analogue*

Figure CCITT-50610, p.

List of timers:

T1: Recommendation Q.412 (§ 2.2.2.7)

T5: 100 ms Recommendation Q.412 (§ 2.2.2.1)

Automatic restoration of an abnormally blocked circuit Recommendation Q.490 (§ 6.6)

n: number of attempts made

T4: 30 s to 2 mn

T7: 2 to 3 s

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Figure CCITT-60971 (Sheet 1 of 5), p.

Figure CCITT-60981 (Sheet 2 of 5), p.

Figure CCITT-60991 (Sheet 3 of 5), p.

Figure CCITT-70001 (Sheet 4 of 5), p.

Figure, p.