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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

General characteristics of international telephone connections and circuits – Protection and restoration of transmission systems

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CHARACTERISTICS OF N + M TYPE DIRECT TRANSMISSION RESTORATION SYSTEMS FOR USE ON DIGITAL SECTIONS, LINKS OR EQUIPMENT

Reedition of CCITT Recommendation G.180 published in the Blue Book, Fascicle III.1 (1988)

NOTES

1 CCITT Recommendation G.180 was published in Fascicle III.1 of the *Blue Book*. This file is an extract from the *Blue Book.* While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation G.180

CHARACTERISTICS OF N + M TYPE DIRECT TRANSMISSION RESTORATION SYSTEMS FOR USE ON DIGITAL SECTIONS, LINKS OR EQUIPMENT

(Melbourne, 1988)

1 General

Transmission restoration functions are often implemented in the modern telecommunication networks to improve the availability and quality of service, by minimizing the effects or potential effects of a transmission failure, and to make the maintenance operations easier.

The terminology and general principles of transmission restoration are described in Recommendation M.495. The functional organization for automatic transmission restoration is described in Recommendation M.496.

2 Object of Recommendation

This Recommendation specifies the characteristics of equipment for N + M type direct transmission restoration systems (protection link switching) for digital transmission links (see Recommendation G.701). The general arrangement of a system for N + M direct transmission restoration is shown in Figure 1/G.180. This Recommendation refers to the equipment labelled as □RSE (Restoration Switching Equipment) and □RSCE (Restoration Switching Control Equipment).

This Recommendation is intended also to cover the case where the signals at the interfaces T belong to different hierarchical levels. In this case, each access at one side can be a group of accesses as indicated in the example of Figure 2/G.180. The left part of this figure refers to the particular case where the restored path is not on a complete link but just through a multiplex equipment.

Note - The equipment specified in this Recommendation can possibly be used also for N + M automatic or semi-automatic transmission rerouting (protection network switching) but generally this type of restoration function is implemented by different equipment, often incorporating also other functions (such as, for example, automatic digital distribution frames). This type of equipment is under study.

Three types of direct transmission restoration systems are considered by this Recommendation:

The first one should permit routing of any one of N normal links on to any one of M restoration links.

The second type should permit the interconnection of any of the N accesses to any one of the N + M links.

The third one should permit routing of any one of N normal links to a single restoration link (in many cases this type can be considered just a special case of the first type).

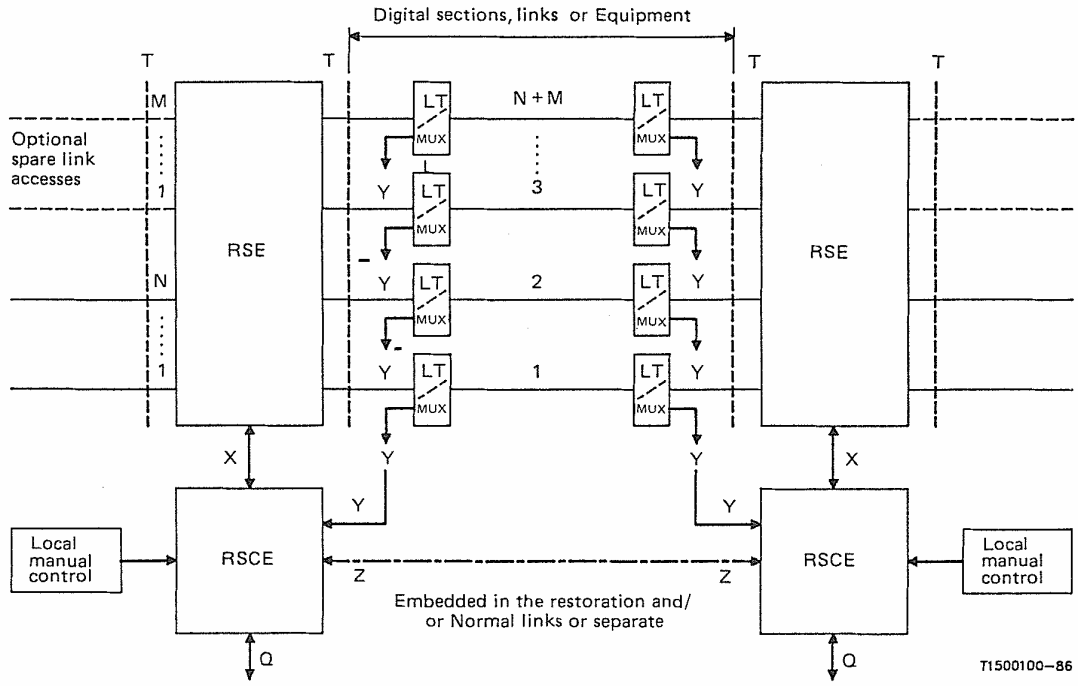
For all the types two options exist:

a) to switch the two directions of transmission independently; and

b) to switch the two directions of transmission simultaneously.

This Recommendation does not cover the restoration systems fully embedded in transmission systems and the 1 + 1 systems where the switching occurs at the receive end only (see Recommendation G.181).

The hierarchical levels at interfaces T are those specified in Recommendation G.702 (hierarchy levels 1 and up).



RSE Restoration switching equipment
RSCE Restoration switching control equipment
LT MUX Line terminal or multiplex
This link can be replaced by connection in the THN

X Non-standardized (or standard Q) interface. If RSE and RSCE are combined interface X does not exist.
Y Interface to be standardized in the future (possibly standard Q)
Z Interface possibly to be standardized
Q Optional standard Q interface to the TMN (telecommunication management network) or to a control centre
T Transmission path interfaces

Note 1 – The failing of a section or link can possibly be detected in the RSE and the information transferred to the RSCE. In this case interface Y may not exist.

Note 2 – The interworking with the TMN via interface Q is at present beyond the scope of the Recommendation.

Note 3 – The N + M digital links or sections can be in the same cable or follow different routes.

Note 4 – Spare link accesses may be used to convey low priority traffic.

Note 5 – The interface between the RSCE and local manual control is not standardized and it is not covered by this Recommendation.

FIGURE 1/G.180

N + M direct restoration system

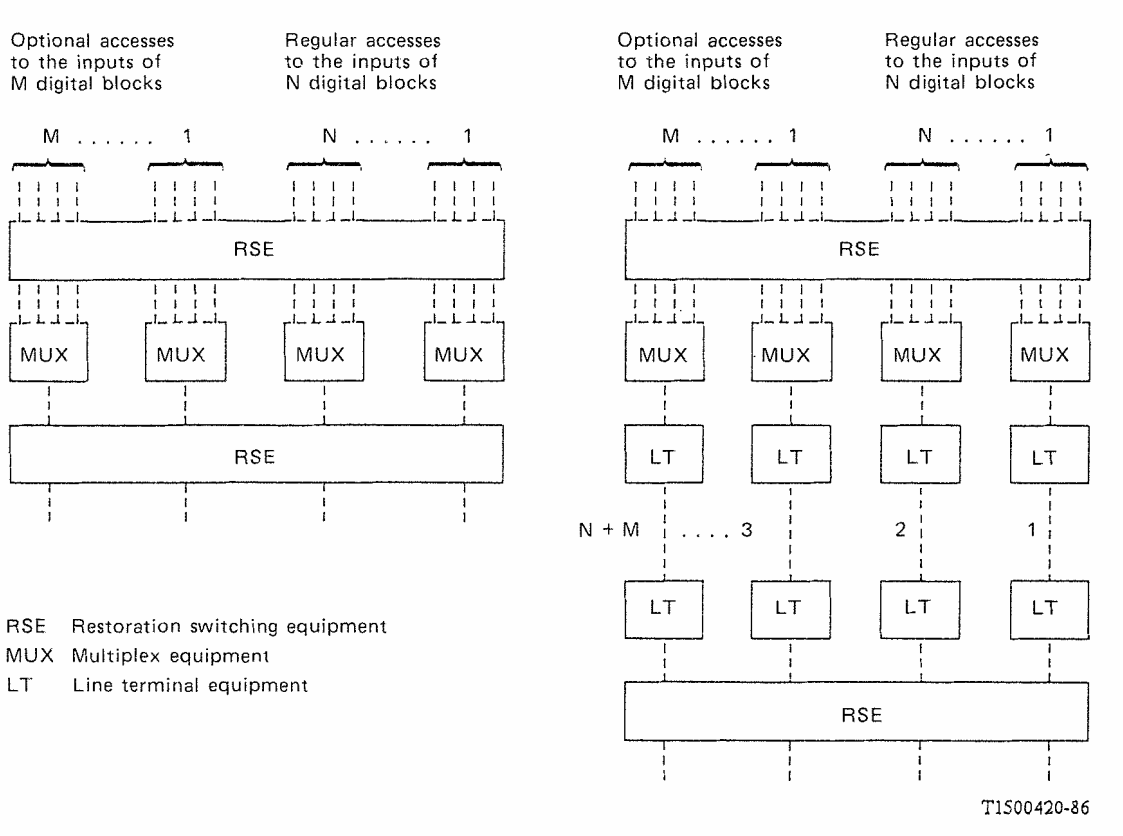


FIGURE 2/G.180

Examples of restoration systems where the hierarchical levels at the two ends are different

3 RSE specifications

Two types of RSE are considered by this Recommendation: the "regenerative" and the "non-regenerative" ones.

The first type, where the digital signal undergoes a complete process of retiming and reshaping, makes the RSE a digital equipment and it is sometimes considered to be advantageous, e.g. from the station cabling point of view.

The second type, where the output signal is proportional to the input signal (except for minor distortion) is considered to be useful in some circumstances, e.g. from a reliability and cost point of view.

3.1 *Interfaces*

3.1.1 *Transmission path interfaces (T)*

The relevant parameters and the recommended values are listed in the uppermost part of Table 1/G.180 for the non-regenerative RSE and in the uppermost part of Table 2/G.180 for the regenerative RSE.

TABLE 1/G.180

Provisionally recommended values for the interface and transfer characteristics of non-regenerative RSE

INTERFACE	Nominal impedance	As stated in Rec. G.703
	Return loss at the input port (with the output port terminated on the nominal impedance)	*z* dB above the values stated in Rec. G.703 (Note 1)
	Accepted levels	The output levels considered in Rec. G.703
TRANSFER	Transfer function between the input and the output of the RSE (terminated on the nominal impedances) (Note 2)	< *x*% of the interconnecting pair loss and phase distortion allowed in Rec. G. 703 for the relevant hierarchical level, or the complement thereof, plus or minus *y* dB flat loss. It is assumed that the loss vs frequency distortion approximates to the $\sqrt{f}$ law (Notes 3 and 4)
	Crosstalk attenuation	> Y_1 dB from any channel > Y_2 dB multi-channel interference evaluated on a voltage-sum basis. These values apply up to a frequency value equal to the nominal bit-rate (Note 5)

Note 1 – The value for *z* is under study. A possible value is *z* = 6 dB.

Note 2 – As a corresponding requirement is under study to permit the connection of test equipment in protected monitoring points, the relevant specification could alternatively be adopted.

Note 3 – The values of *x* and *y* are under study. A proposal states: *x* = 10% and *y* = 0.5 dB.

Note 4 –A delay limit will be also considered in future if benefit is expected from that.

Note 5 – The Y_1 and Y_2 limits are under study. y_1 = 40 and y_2 = 30 have been proposed as compromise values among different proposals. Different limits could possibly be adopted for RSE having a different configuration (e.g. N + 1 or N +M).

3.1.2 *Control interfaces*

The only control interface of the RSE is X. This interface is not at present specified by the CCITT. However in the future, it may be specified as a Q interface (see Recommendation G.771).

If the interface X is not standardized, the separation between the RSE and RSCE (and consequently between §§ 3 and 4 of this Recommendation) will be somewhat arbitrary.

3.2 *Operational aspects*

3.2.1 *Transfer of the switched signals*

The relevant parameters and the recommended values are listed in the lower part of Table 1/G.180 for the non-regenerative RSE and in the lower part of Table 2/G.180 for the regenerative RSE.

TABLE 2/G.180

Interface and transfer characteristics recommended for regenerative restoration switching equipment

General			
INTERFACE	Nominal bit rate and tolerance	As stated in Rec. G.703
	Connecting pairs Test impedance and return loss at the input ports Pulse shape and levels Tolerable input jitter	As stated in Rec. G.703
	Intrinsic output jitter	As stated in Supplement B to Table 2/G.180
TRANSFER	Jitter transfer	As stated in Supplement A to Table 2/G.180
	Error performance	99.99% error-free seconds (Note 3)
	Others (Note 1)	The paths across each switch shall maintain bit sequence independence and integrity (Note 2)

Note 1 – A delay limit will also be considered in future if benefit is expected from that.

Note 2 – Further study is necessary whether or not the digital signal should be replaced by a signal other than AIS in a restoration switching condition.

Note 3 – Evaluated under maximum loading condition and excluding any external source of interference.

3.2.2 *Response*

For RSE providing M restoration paths to N normal paths (M = 1 included) it is recommended that in response to a RSCE command the RSE should apply the incoming interface signal belonging to a given normal link to the input port of a given restoration link. The signal should not be removed from the input port of the concerned normal link, except that it may be replaced by a test signal.

For RSE providing N + M link to N accesses it is recommended that in response to a RSCE command, the SCE should apply the incoming interface signal belonging to a given access from 1 to N to a given link from 1 to N + M.

It is recommended that the time required for the above response actions, that is the "restoration transfer time", should be less than tx ms. The value for tx is under study.

Note – The characteristics necessary to specify the option of detecting in the RSE a failed path and to pass this information to the RSCE are under study.

3.2.3 *Other operational aspects*

A recognized failure of the RSCE or its disconnection from the RSE at interface X (when applicable) should either:

a) Cause the RSE to route all the signals on the N normal links. After the failure of the RSCE is cleared or the RSCE is reconnected to the RSE, normal restoration operations will resume.

b) Not alter the state of the RSE. The cross-connection pattern of the RSE should be available by interrogation from the RSCE to enable it to update, when the failure is cleared or it is reconnected to the RSE, its own record on the cross-connection pattern.

For the restoration systems of the second type (as defined in § 2 of this Recommendation) alternative b) only holds. For the systems of the first and third types both alternatives are applicable.

Note – The recommended behaviour of the RSE in case of own power failure is under study.

4 RSCE specifications

4.1 *Interfaces*

Interfaces Y, Z and Q of the RSCE (see Figure 1/G.180) are under study, including the bit rate and the tolerable bit error ratio for the Z interface.

4.2 *Operational aspects*

4.2.1 *Responses*

A switching to a restoration link should be initiated under a request coming from interfaces Y, Z, Q (and X where the faults are detected within the RSE) or on command from the local manual control.

When decided in the RSCE the allocation of a restoration link can optionally take place according to defined priority rules based on:

- defined priority for each normal link;
- request type (low or high priority request).

Otherwise the allocation should be specified by the information coming from interfaces Z, Q or local manual control.

For the restoration systems providing M restoration links (M = 1 included) on N normal links, when a successful restoration request clears, traffic should be returned to the pertinent normal link and the pertinent restoration link should be released.

It should be possible from interfaces Z, Q and under local manual control to lock in a working link (e.g. during system maintenance).

The time required for the above recommended restoration action is the sum of the "waiting time" and the "restoration procedure time". The two components should remain within the following limits:

- waiting time (under study);
- restoration procedure time (under study).

Note – Values to be recommended may be different for the three types of systems considered under § 2 and could depend on the interface over which the information is transferred. No precise proposed value exists at the moment. For a N + 1 system, one proposal indicates that the sum of the "restoration procedure time" and of the "restoration transfer time" should not exceed, in 90% of the occasions, 50 ms plus the time required for the communications.

4.2.2 *Alarm and status criteria*

Under study (see Appendix I to this Recommendation).

4.2.3 *Monitoring and self-test procedures*

Under study (see Appendix II to this Recommendation).

SUPPLEMENT A

(to Table 2/G.180)

Maximum permissible intrinsic jitter at output ports of regenerative restoration switching equipmemt

(Values for bit rates of the 1544 kbit/s digital hierarchy are under study)

For asynchronous space matrix RSE

Parameter value / Digital rate (kbit/s)	Maximum value Unit interval peak-peak	Measurement filter bandwidth	
		Bandpass filter having a lower cut-off frequency f_1 and an upper cut-off frequency f_4	
		f_1	f_4
2 048	0.1	20 Hz	100 kHz
8 448	0.1	20 Hz	400 kHz
34 368	0.075	100 Hz	800 kHz
139 264	0.05	200 Hz	3 500 kHz

Parameter value / Digital rate (kbit/s)	Maximum value Unit interval peak-peak		Measurement filter bandwidth		
			Bandpass filter having a lower cut-off frequency f_1 or f_3 and an upper cut-off frequency f_4		
	B_1 ($f_1 \div f_4$ filter)	B_2 ($f_3 \div f_4$ filter)	f_1	f_3	f_4
2 048	0.25	0.05	20 Hz	18 kHz (700 Hz)	100 kHz
8 448	0.25	0.05	20 Hz	3 kHz (700 kHz)	400 kHz
34 368	0.35	0.05	100 Hz	10 kHz	800 kHz
139 264	under study	0.05	200 Hz	10 kHz	3 500 kHz

Note 1 – UI Unit interval

for	2 048	kbit/s 1 UI	488	ns
for	8 448	kbit/s 1 UI	118	ns
for	34 368	kbit/s 1 UI	29.1	ns
for	139 264	kbit/s 1 UI	7.18	ns.

Note 2 – These figures shall be met for any valid signal in the absence of input jitter. The measurement shall be implemented using equipment designed in accordance with CCITT Recommendation O.171.

Note 3 – Recommendation G.823 § 2 indicates the measurement method.

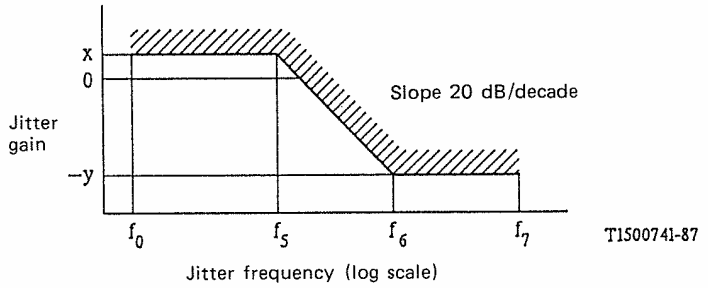
Note 4 – The frequency values in parentheses only apply to certain national interfaces.

SUPPLEMENT B

(to Table 2/G.180)

Jitter transfer characteristics recommended for regenerative restoration switching equipment

(Values for the bit rates of the 1544 kbit/s digital hierachy are under study.)



Parameter value / Digital rate (kbit/s)	x (dB) (Note 5)	$-y$ (dB)	f_0 (Hz)	f_5 (kHz)	f_6 (kHz)	f_7 (kHz)	Test signal (pseudo- random as Rec. O.151)
2 048	0.5	–8.4 (–9.5)	(Note 1)	36 (1.4)	100 (4.4)	100	$2^{15} - 1$
8 448	0.5	–9.5 (-7.5)	(Note 1)	6 (160)	19 (400)	400	$2^{15} - 1$
34 368	0.5	–9.5	(Note 1)	20	64	800	$2^{23} - 1$
139 264	0.5	–9.5	(Note 1)	20	64	3 500	$2^{23} - 1$

Note 1 – The frequency f_0 should be as low as possible (e.g., 10 Hz) taking into account the limitations of measuring equipment.

Note 2 – The measuring method should be selective with a bandwidth sufficiently small referred to the relevant measuring frequency, but not wider than 40 Hz.

Note 3 – In the f_6 to f_7 frequency range the jitter gain should be less than y dB, with the exception of spurious responses, which should be suppressed below -6 dB.

Note 4 – The frequency values shown in parentheses only apply to certain national interfaces.

Note 5 – A value of 0.2 dB has been suggested as technically possible for this type of equipment. This may be useful where large numbers of RSE are employed in the network.

Parameter value / Digital rate (kbit/s)	x (dB)	$-y$ (dB)	f_0 (Hz)	f_5 (kHz)	f_6 (kHz)	f_7 (kHz)	Test signal (pseudo-random as Rec. O.151)
2 048	0.5	19.5	(Note 1)	40	400	100	$2^{15} - 1$
8 448	0.5	19.5	(Note 1)	100	1 000	400	$2^{15} - 1$
34 368	0.5	19.5	(Note 1)	300	3 000	800	$2^{23} - 1$
139 264	0.5	under study	(Note 1)	900	under study	3 500	$2^{23} - 1$

Note 1 – The frequency f_O should be as low as possible (e.g., 10 Hz) taking into account the limitations of measuring equipment.

Note 2 – The measuring method should be selective with a bandwidth sufficiently small referred to the relevant measuring frequency, but not wider than 40 Hz.

Note 3 – The need to tolerate spurious responses greater than y dB in the frequency range $f6$ to f_7 is for further study.

APPENDIX I

(to Recommendation G.180)

Proposals for alarms and status criteria
(Both refer to a N + 1 system)

<table>
<tr><th>Proposed by STC PLC</th><th>Proposed by AT&T and Philips Telecommunications</th></tr>
<tr><td rowspan="2">Alarms
It is proposed that the system should include :

a) System fail.
b) Protection failure.
c) Manual switch in operation.
d) System software self check in operation.
e) Control system failure.
f) System software failure.
g) Communication failure.
h) Stand-by channel failure.
i) Power supply failure.
j) Card removal</td><td>Separate alarm criteria shall be issued at the occurrence of the following faulty conditions:

a) Loss of signal at the traffic input port, transmit side.
b) Loss of signal at the traffic output port, receive side.
c) Automatic lock-in (see Note).
d) Switch failure.
e) Protection failure.
f) Control system failure.
g) Communication failure.
h) Stand-by channel failure.
i) Power supply unit failure.
j) Loss of power supply.
k) Switch exerciser failure.

Separate status criteria shall be issued, on the occurrence of the following situations:
a) Switch operated.
b) Switch locked.
c) Switch request pending.
d) Switch in manual mode.

The protective switching control equipment shall make available to the remote control and maintenance centre alarm and status information corresponding to the criteria shown above.</td></tr>
<tr><td>Note – This system is required to automatically lock in the normal or the protection channel if an excessive number of switching operations are made in a given period.</td></tr>
</table>

APPENDIX II

(to Recommendation G.180)

Proposals for monitoring and self-test procedures
(Both refer to a N + 1 system)

Proposed STC PLC	*Standby Channel Monitoring* The system should include means of monitoring the standby channel continuously for proper operation. *Self-check* The system should include self-check facilities as follows: a) Communication channel. b) Background-checking of the memory, coaxial relay drive buffer and other hardware. c) Correct programme execution.
Proposed by AT&T and Philips Telecommu-nications	*Standby Channel Monitoring* The standby channel shall be monitored continuously for proper operation. *Switch Exerciser* The protective switching system shall provide a switch exerciser meeting the following requirements: The exerciser shall test the complete switch-over procedure up to but excluding the last transfer switch in the direction of transmission. The switching system shall drop the exerciser routine and serve switch requests from failed or deteriorated channels. A facility for including the last switch in the exercise routine may be provided. This feature shall have the capability of being disabled.

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