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SETTING UP AND LINING UP ANALOGUE CHANNELS

FOR INTERNATIONAL TELECOMMUNICATION SERVICES

1 Check of channel-translating equipment

The translating equipment, before it is connected to the ends of the link, must be checked and adjusted to ensure that it meets CCITT Recommendations and the other relevant specifications. The check should include a general visual inspection and vibration tests, if applicable. This is of particular importance if the equipment has remained unused since acceptance tests were carried out after installation.

Recommendation M.470

2 Setting up and lining up the analogue channels

2.1 *Measurement and adjustment of levels*

After the group link has been set up, and the channel-translating equipment at each end of the group link has been connected and checked, the channels are adjusted as follows.

An 1020 Hz test signal is sent over each channel in turn at a level of —10 dBm0. At the transmitting end, the channel-translating equipment is adjusted so that the sideband level on each channel at its output is as near to nominal as possible. At the receiving end, the channel-translating equipment should then be adjusted to bring the received level on each channel as near as possible to its nominal value.

2.2 *Checking the analogue channel performance*

Channel performance measurements are only required when the need is indicated during circuit line-up. On such occasions the parameters to be checked will depend on the particular difficulty experienced during circuit line-up.

3 Check level of line signalling

In the case of groups which are intended to be used for telephone circuits employing Signalling System R2, the checks of signalling level stipulated in the Specifications of Signalling System R2 should be made [2].

For other signalling systems, the check of signalling level should be carried out at the circuit line-up stage (see Recommendation M.580, § 8).

For further information about the choice of the test signal frequency, refer to Recommendation O.6 [1].

References

[1] CCITT Recommendation *1020 Hz reference test frequency* , Vol. IV, Rec. O.6.

[2] CCITT Recommendations *Specifications of Signalling System R2* , Vol. VI, Recs. Q.400 to Q.490.

Recommendation M.475

SETTING UP AND LINING UP MIXED ANALOGUE/DIGITAL

CHANNELS FOR INTERNATIONAL TELECOMMUNICATION SERVICES

1 Check of FDM multiplex or transmultiplexer equipment

The FDM multiplex or transmultiplexer equipment, before it is connected to a group or supergroup link, must be checked to ensure that it meets CCITT Recommendations and the other relevant specifications. The check should include a general visual inspection and vibration tests, if applicable. This is of particular importance if the equipment has remained unused since acceptance tests were carried out after installation.

2 Setting up and lining up mixed analogue/digital channels

The definition of a mixed analogue/digital channel is given in Recommendation M.300. When these channels are used for international telephone

circuits, the required circuit transmission loss will in many cases be established through the use of variable loss pads in the transmultiplexer. For these mixed analogue/digital channel applications, Administrations may, through bilateral agreement, defer the separate channel line-up procedures contained in this Recommendation, and perform, instead, the appropriate circuit section and circuit line-up procedures of Recommendation M.580.

As a prerequisite to setting up and lining up channels using the procedures in this Recommendation, the involved group and supergroup links shall have been set up and lined up in accordance with Recommendation M.460.

2.1 *Measurement and adjustment of levels*

Depending upon the type of test equipment used, and the access features of the transmultiplexer, the following procedures may require taking an entire transmultiplexer out of service while each channel is being lined up. Careful consideration should be given to procedures for removing transmultiplexers from service, and for restoring them to service, especially where the group links which terminate on the transmultiplexer are not

co-terminous, or where international leased circuits are provided on transmultiplexers.

2.1.1 *Transmultiplexers at each end of the group or supergroup link*

For further information about the choice of the test signal frequency, refer to Recommendation O.6 [1].
Note — These configurations are shown in a) and b) of Figure 1/M.475.

After the group or supergroup links have been set up, and the transmultiplexing equipments at the ends of the group or supergroup links have been checked and connected, the channels are adjusted as follows.

At the transmitting end, a bit sequence corresponding to 1020 Hz test tone at a level of —10 dBm0 is applied to the 64 kbit/s time slot appearance of each channel in turn, at the digital path access point associated with the input to the transmultiplexer, using appropriate digital test equipment. At the receiving end, the 64 kbit/s time slot appearance of each channel is monitored in turn at the digital path access point associated with the output of the transmultiplexer, using appropriate digital test equipment, and each channel is adjusted as near as possible to its nominal level.

2.1.2 *24-channel transmultiplexer at one end of the group links, with channel translating equipment at the other end*

Note — This configuration is shown in c) of Figure 1/M.475.

After the group links have been set up, and the transmultiplexing and channel translating equipments at the ends of the group links have been checked and connected, the channels are adjusted as follows.

Transmitting from the channel translating equipment towards the transmultiplexer, an 1020 Hz test signal is sent over each channel in turn at a level of —10 dBm0. The channel translating equipment is adjusted so that the sideband level on each channel is as near to the nominal level as possible. At the receiving end, the 64 kbit/s time slot corresponding to each channel is monitored in turn at the digital path access point associated with the output of the transmultiplexer, and each channel is adjusted to obtain the bit sequence corresponding to the nominal level of the received test signal.

Figure 1/M.475, p.

Transmitting from the transmultiplexer towards the channel translating equipments, a bit sequence corresponding to 1020 Hz test tone at a level of —10 dBm0 is applied to the 64 kbit/s time slot of each channel in turn, at the digital path access point associated with the digital input to the transmultiplexer, using appropriate digital test equipment. At the receiving end, the channel translating equipment should then be adjusted to bring the received level on each channel as near as possible to its nominal value.

2.1.3 *60-channel transmultiplexer at one end of a supergroup link, with group and channel translating equipments at the other end*

Note — This configuration is shown in d) of Figure 1/M.475.

After the supergroup link and group links have been set up, and the transmultiplexing, group translating, and channel translating equipments at the ends of the supergroup link and group links have been checked and connected, the channels are adjusted by the following procedures in § 2.1.2 above.

3 Check level of line signalling

In the case of groups which are intended to be used for telephone circuits employing Signalling System R2, the checks of signalling level stipulated in the Specifications of Signalling System R2 should be made [2].

For other signalling systems, the check of signalling level should be carried out at the circuit line-up stage (see the Recommendation M.580).

References

[1] CCITT Recommendation *1020 Hz reference test frequency* , Vol. IV, Rec. O.6

[2] CCITT Recommendations *Specifications of Signalling System R2* , Vol. VI, Recs. Q.400 to Q.490.

2.4 Planned outages and restoration of transmission systems

Recommendation M.490

EXCHANGE OF INFORMATION FOR PLANNED OUTAGES OF TRANSMISSION SYSTEMS

1 General

Planned outages of transmission systems are required to allow planned work to be done with the minimum impairment to the service concerned. All tests, measurements, rearrangements, etc., which are not attributed directly to a failure — and are known in advance — are considered to be *planned work* . Such work will include installation of new equipment, routine maintenance, work on power supply equipment and in some cases, work for the clearance of faults which at first could only be remedied provisionally (mainly cable faults).

In the event of planned work which results in the complete or partial interruption in a transmission system, efforts are at first made to reroute the telecommunication traffic as required. If special restoration plans exist for cases of faults, these plans can also be used in the event of planned outages. Should rerouting be impossible, planned work is generally carried out during periods of light traffic, e.g. at night. To allow appropriate measures to be taken, all stations affected by the planned outage must be informed in good time.

2 Planned outages of international groups, supergroups, etc.

When an Administration plans the outage of a transmission system carrying international group/supergroup, etc. links, it should inform all other Administrations in whose territories the links concerned terminate. This information should be given by telex at least three working days in advance. An example is given in Figure 1/M.490. There are cases in which more than three days are necessary, such as those involving extensive rearrangements. If, in exceptional cases, a three-day notice cannot be given, advice should be given by telephone so as to ensure that the Administrations concerned still have sufficient time to take the appropriate steps. Planned outages should not be carried out if notice cannot be given and received at least 24 hours in advance.

In practice, Administrations have entrusted different entities, i.e. either their international centres or their technical services with the exchange of information for planned outages. Therefore, it is essential that each Administration states clearly to whom reports on outages are to be sent of the outages planned in its own country, and try to reduce their impact on international services to a minimum. Passing on of the information within the area of an Administration, e.g. to the control stations for leased and special circuits, or to the users of leased circuits, is done according to the national practice.

3 Planned outages of national transmission systems, which affect international leased and special circuits

In the international centres, international leased and special circuits are frequently through-connected in the voice-frequency band and routed to the destination via national group links. An outage of these group links leads to a break in the international circuit. In these cases, informing the circuit control station and the users is of particular importance in order to avoid unnecessary fault location in the other country.

If an outage is planned for a national system within the area of the Administration being entrusted with the terminal sub-control function for a circuit, the circuit control station should be informed direct or via the two transmission maintenance points (international line) (see Recommendation M.1014 [1] or via the technical service so as to enable the control station to inform the user in good time. In addition, it may be advisable that the terminal

sub-control station informs the user at its end of the circuit of the planned outage, since an exchange of information between the users at both ends of the circuit is not always possible. Figure 2/M.490 illustrates the possible flow of information for this case.

A similar procedure should be applied if a planned outage of a national system in a transit country affects an international leased or special circuit.

If an outage is planned for a national system within the area of an Administration having control functions for a circuit, it is recommended that the sub-control station be advised in order to avoid unnecessary queries in the event of a fault report being submitted by the user in the distant country concerned. The transmission maintenance point (international line) in its own country should be informed in any case.

The time limit of three working days is not intended to affect other agreements in special cases, e.g. a notification time of two weeks in planned outages of submarine cable systems.

Normally such information is exchanged between the System Availability Information Points (see Recommendation M.721).

Figure 1/M.490 [T1.490], p. 2

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Figure 2/M.490, p. 3

Reference

[1] CCITT Recommendation *Transmission maintenance point international line (TMP-IL)* , Vol. IV, Rec. M.1014.

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Recommendation M.495

TRANSMISSION RESTORATION AND TRANSMISSION ROUTE DIVERSITY:

TERMINOLOGY AND GENERAL PRINCIPLES

1 Purpose of transmission restoration and transmission route diversity

The purpose of transmission restoration and transmission route diversity is to protect the continuity and quality of international telecommunication services by minimizing the effects of potential effects of a transmission failure.

This Recommendation applies to both analogue and digital transmission.

Note — This Recommendation may also apply in the case of hazardous conditions.

2 Causes of transmission failures

The causes of transmission failures can be divided into three major categories:

— equipment failure: this can be reduced by improving equipment reliability;

— outages due to the operating organization. For example, maintenance work or human errors;

— external causes which are very difficult to prevent and for which specific protection might be needed. For example weather conditions or excavation work.

In this Recommendation, failures or faults that are referred to may be either total or partial failures or faults. The relevant terminology concerning failures and faults can be found in Supplement No. 6 [1].

3 Definitions concerning transmission restoration and transmission route diversity

The purpose of this terminology is to define a vocabulary which can be used in connection with transmission restoration and transmission route diversity.

Note — In this terminology, the term ‘‘link’’ is used as a generic term for digital section, digital path, group link or section, supergroup link or section, mastergroup link or section, supermastergroup link or section, line section, section and line link.

3.1 *Basic concepts*

3.1.1 **transmission restoration**

The different actions taken in order to restore the transmission of a signal affected by a transmission fault.

3.1.2 **transmission restoration function**

The ability to perform under stated conditions and within given time constraints the transmission restoration.

Note 1 — This function is aimed at increasing the transmission availability; it can provide transmission link supervision and control, the sending and receiving of control and check signals, and the changeover from normal to an alternative link, if necessary by assembling links.

Note 2 — This function can allow the restoration of failed transmission systems, links, groups, digital blocks, equipment, etc., as well as the restoration for maintenance purposes such as planned outages, or to remedy conditions that affect transmission such as fading.

Note 3 — The transmission restoration function can be implemented by equipment that is dedicated to it, or by equipment that has other functions, such as, for example, automatic digital distribution frames.

3.1.3 **transmission restoration function: direct transmission restoration (protection link switching)**

Direct transmission restoration is that category of transmission restoration function in which one transmission link between two stations is substituted for another between those two stations.

Note — This reflects a configuration in which M links proctect N links, or in which N+M links give redundancy to a relation requiring N links, with the extremities of all links in the same locations. It is recommended to use the expression N+M direct transmission restoration to designate such a configuration. See Figure 1/M.495.

Figure 1/M.495, p.

3.1.4 **transmission restoration function: automatic or semi-automatic transmission rerouting (protection network switching)**

Automatic or semi-automatic transmission rerouting is that category of transmission restoration function in which transmission links are assembled together and substituted for another link.

Note — This reflects a configuration in which a certain number of links form a restoration network and protect normal links. Within a given transmission station, or for a given switching equipment, M links protect N links. It is recommended to use the expression N+M automatic transmission rerouting to designate such a configuration.

Figure 2/M.495 shows un example. In Station A, M restoration links can be used for restoration of N normal. A link between A and B can be restored, for example, directly or via C.

Figure 2/M.495, p.

3.1.5 **transmission restoration function: 1+1 restoration**

1+1 restoration is that category of transmission restoration function in which one transmission link is substituted for another associated link, generally on another transmission route. See Figure 3/M.495.

Figure 3/M.495, p.

3.1.6 **transmission restoration function: manual transmission rerouting**

Manual transmission rerouting is that category of transmission restoration function in which one transmission link is replaced manually by another when a complete or partial transmission route failure has occurred or when the normal route restoration link is not available due to a previous or simultaneous interruption, or when there is no such restoration link provided.

Note — Such rerouting is normally effected using plugs and cords.

3.1.7 **transmission restoration control function**

This is the function which decides whether restoration is necessary on the basis of information from the link supervision system or link alarms.

Note — The control function might be included in a specific equipment, or in the transmission restoration equipment itself, or within a restoration control centre. Control decisions can also be taken by people in, for example, a control centre.

3.2 *Systems and equipment*

3.2.1 **transmission restoration system**

A system that can be used to implement the transmission restoration function. An example is shown in Figure 4/M.495.

3.2.2 **transmission restoration equipment**

The part of the transmission restoration system that switches the transmission from the normal link to a restoration link.

3.2.3 **normal transmission link/equipment; normal digital block, group, supergroup, etc.**

A transmission link/equipment or a digital block, group, supergroup, etc., which is used for transmission under normal operating conditions.

3.2.4 **restoration link/equipment**

A transmission link/equipment which is used for transmission when the normal link/equipment is not available.

Note 1 — A restoration link or equipment is generally idle under normal operating conditions, but might be used under these conditions by low-priority traffic for which a lower degree of service availability is accepted.

Note 2 — Note 1 may not apply to 1+1 type restoration system where both links are carrying the traffic.

3.2.5 **restoration network**

The network formed by all restoration links.

Figure 4/M.495, p.

3.3 *Control* (see also Figure 5/M.495)

3.3.1 **control equipment**

An equipment that is used to implement the transmission restoration control function.

3.3.2 **restoration control centre**

A centre supervising all or part of normal and restoration transmission systems.

Note — A restoration control centre can be included within a control centre which is not dedicated to restoration.

3.3.3 **controlled station**

The station that has its systems, links and other maintenance elements supervised, where the information and commands for switching are sent to and received from, the control centre, and where the switching is effected.

3.3.4 **restoration unit**

All normal and restoration links and associated switching equipment capable of being controlled from a particular control centre.

Note — Some networks areas may be controlled from more than one control centre.

3.3.5 **control circuit**

A circuit used for the transmission of restoration control information.

Figure 5/M.495, p.

3.4 *Time intervals associated with transmission restoration processes*

The following time intervals are intended to describe the different time components between the failure of a signal and its restoration. These time intervals can be used to characterize those transmission restoration systems, equipment etc. See also figure 6/M.495.

Figure 6/M.495, p.

3.4.1 **detection time, T_1**

Time interval between a potential failure of transmission and the recognition of that potential failure.

3.4.2 **waiting time, T_2**

Time interval after the recognition of a potential failure and its confirmation as a fault requiring restoration.

3.4.3 **restoration procedure time, T_3**

Time interval between the confirmation of a fault and completion of the processing and transmission of the control signals required to effect restoration.

3.4.4 **restoration transfer time, T_4**

Time interval between completion of the processing and transmission of the control signals required to effect restoration and the completion of transmission restoration operations.

3.4.5 **recovery time, T_5**

Time interval between the completion of transmission restoration operations and the full restoration of failed transmission.

Note — This may include the verification of switching operations, re-synchronization of digital transmission, etc.

3.4.6 **confirmation time, T_c**

The time from the occurrence of the potencial failure to the instant when the fault is confirmed as requiring a restoration: $T_c = T_1 + T_2$.

3.4.7 **transfer time, T_t**

The time interval after the confirmation that a fault requires a restoration to the completion of the transmission restoration operation; $T_t = T_3 + T_4$.

3.4.8 **restoration time, T_r**

The time from the occurrence of the failure to the restoration of the faulty transmission: $T_r = T_1 + T_2 + T_3 + T_4 + T_5$ = confirmation time + transfer time + T_5.

Note — An apparent fault might be detected by an equipment and not confirmed after the confirmation operations. In this case, only times T_1 and T_2 are relevant.

3.5 *Software related terms*

3.5.1 **network image**

Software description of the transmission network to be protected.

3.5.2 **fault definition program**

Program which collects fault information and defines faulty transmission links.

3.5.3 **restoration algorithm**

Method for forming restoration links for faulty normal transmission links.

3.5.4 **restoration control program**

A decision making program which controls restoration processes.

3.6 *Route diversity*

3.6.1 **transmission route**

A transmission facility on a specific medium used by a certain number of transmission systems between two stations.

Note 1 — For example, one cable between two stations could be regarded as one transmission route (whatever the number of systems using this cable might be) and a radio system between these two points could be regarded as an other route.

Note 2 — This definition represents a physical route; this is different from the term ‘‘route’’ which is defined in the Recommendations E.600 [2], Q.9 [3] and Z.341 [4], which represents a logical route.

3.6.2 **transmission route diversity**

The provision of at least two links between two nodes in a transmission network which are routed over different transmission routes.

Note — In case of a failure of one link, transmission route diversity allows some traffic between the two nodes still to be carried over the remaining link(s).

4 Principles of transmission restoration and transmission route diversity

4.1 *General principles*

4.1.1 In case of a fault of an international transmission system, complete and fast transmission restoration is a maintenance objective. Line and terminal equipment allocated for transmission restoration should be left available to the extent that the objective can be achieved. This equipment may sometimes be used for other purposes as required, e.g., planned outages.

4.1.2 When planning new routes or changes to existing routes, account should be taken of the requirements of restoration.

4.1.3 The responsibility for restoration should be based on the following principles in the case of an interruption due to a fault or to a planned outage of a transmission link:

a) when the fault of an international transmission link takes place on a national section, restoration is solely the affair of the Administration involved;

b) when a fault takes place on an international section of an international route, restoration is the affair of the Administrations of the two countries directly involved, even if Administrations of other countries are concerned;

c) in the case of a satellite fault, the responsibility to restore the satellite capability rests with the designated satellite system manager;

d) restoration should be effected in the transmission network at the highest order of link permitted by the network (group link, supergroup link, etc.) taking into account the service which is carried;

e) it would be desirable to arrive, if possible, at complete restoration based upon bilateral and/or multilateral agreements. Special consideration is necessary when, in practical cases, complete restoration cannot be achieved. When complete restoration is not possible the links to be restored should contain those circuits that satisfy the special needs of the Administrations involved to the extent possible. Sufficient restoration capacity should therefore be provided to reflect the special interests of each Administration involved. Certain services might be considered as priority services by bilateral agreements; in this case, they should be grouped on groups or digital blocks that are restored in priority;

f) in the case where it is not possible to restore all circuits through the procedures envisaged under a), b), and c), each terminal Administration should make the necessary agreements to use all available routes lending themselves to restoration.

4.2 *Transmission restoration systems*

The following points regarding transmission restoration systems should be noted:

a) in the case when a transmission restoration network exists, it might be used under normal operating conditions for preemptible traffic. However, the restoration time might be a little longer when low priority traffic has to be interrupted before the restoration;

b) transmission restoration systems might be used for specific maintenance purposes such as planned outages. In this case, a planned restoration should be effected in such a way that the resulting impact on tranmission quality and availability is minimized;

c) certain normal transmission links may have a priority restoration, with preemption on restoration links. On these links should be routed groups and digital blocks bearing services that are considered having priority;

d) in general, when the normal transmission link can be used again, transmission is switched back from the restoration link. This switch-back can be made manually, semi-automatically or automatically; it should be made in such a way that the resulting impact on transmission quality and availability is minimized;

e) in certain cases, restoration of transmission might be effected separately for the receive and transmit directions;

f) in case of automatic or semi-automatic restoration systems, there should be a possibility of manual action for a forced restoration or an inhibition. This action has to be possible semi-automatically for automatic restoration systems;

g) transmission restoration systems should be built in such a way that a fault of one of its components or a maintenance action on it will result, in most cases, in minimal impact on normal transmission quality and availability.

4.3 *Transmission route diversity*

Transmission route diversity is a way of protecting circuits groups (a number of circuits with the same terminal points) against the effects of transmission failures. Circuit groups are divided into smaller groups which are carried on different transmission routes. In this way, a transmission faults of one transmission route does not completely interrupt the service.

For example, 60 public circuits between two exchanges can be divided into 2 groups of 30 circuits routed on cable and radio link. See Figure 7/M.495.

Figure 7/M.495, p.

4.4 *Restoration times*

4.4.1 It is useful to consider the restoration system in terms of the component time intervals involved. Some of these have been identified in the above terminology. These time intervals vary depending on whether the transmission system is analogue or digital. In the case of digital, the bit rate is also a factor.

4.4.2 It might be necessary, when specifying restoration times, and especially the confirmation time, to examine the different transmission restoration systems that might be used at the same time on a given link: for example, a 1+1 restoration system with its normal link beared by a transmission system protected by an N+1 direct transmission restoration system.

4.4.3 The aim for restoration time performance objective will come from service interruption objectives which were currently under study by CCITT.

There might be different aims for various types of failure and of restoration type: single transmission system or complete transmission route failure; automatic, semi-automatic or manual restoration, etc.

4.5 *Restoration criteria*

The criteria used to decide if a restoration action is necessary can be based upon transmission fault and also occurrence of bad quality (signal-to-noise ratio for analogue transmission, bit error ratio, thresholds of Recommendation G.821 [5] for digital transmission, etc.).

5 Methods of transmission restoration

5.1 *General*

The links provided for transmission restoration can be used in the event of both faults and planned outages. Methods for restoration will necessarily vary according to the particular system and circumstances involved. They will include transmission restoration and physical repair using manual, semi-automatic or fully automatic methods. In order to choose the restoration method, it is appropriate for the Administrations involved to take into account the following elements in a bilateral or multilateral agreement:

a) the level of availability desired;

b) the facilities that may be used for restoration;

c) the economics related to the particular system being considered;

d) the compatibility of transmission equipment at appropriate locations (for example analogue/digital, satellite/coaxial etc.).

5.2 *Automatic restoration*

Automatic restoration is possible with the use of automatic restoration systems, which can be of three main types:

— 1+1 transmission restoration;

— direct transmission restoration (protection link switching);

— automatic transmission rerouting (protection network switching).

The functional organization of these restoration systems is described within Recommendation M.496.

5.3 *Semi-automatic restoration*

Specific equipment and transmission restoration systems are introduced in order to allow automatic restoration. As any interruption of service is undesirable, especially in the case of planned outages, this equipment should generally allow the remote manual activation and control of automatic transmission rerouting systems in order to change from the normal route to a previously set-up and tested restoration route.

5.4 *Manual restoration*

The complexity of the evolving international transmission network demands flexibility in any transmission restoration arrangement. In general, transmission restoration can be achieved by manual switching, for example on analogue or digital distribution frames. In this case a distribution frame is necessary. The links used for transmission restoration are arranged in a network configuration with particular restoration requirements being met by using such links either singly or connected in tandem. This arrangement is flexible and maximizes the use of international restoration links which are expensive to provide and therefore limited in number.

6 Considerations involved in planning transmission restoration systems

6.1 *Parameters to be taken into account:*

Restoration arrangements for transmission systems may be applied at any level in the multiplex hierarchy that is bilaterally or multilaterally agreed upon. The switching configuration itself may be a 1+1 or more complex N+M relationship, involving N normal links being protected by M restoration links. When planning a physical restoration system on an international basis the following considerations, among others, should be taken into account in the context of the desired availability and the economics involved.

a) availability of restoration capacity, taking into account the number of restoration and normal links;

b) transmission characteristics of the restoration link(s);

c) services to be restored and the acceptability of additional delay to confirm a fault and minimize switching (see § 4.4 of this Recommendation);

d) threshold at which fault is to be established (this may be adjustable in a range) (see § 4.5);

e) switching level in the multiplex hierarchy and whether any restorative switching is to be applied at more than one level;

f) manual or automatic switch-back techniques;

g) use of telemetry and control system, if required;

h) the need of a unidirectional or bidirectional system;

i) apportionment to the switches of the maximum degradation of the transmission characteristics (for example, maximum crosstalk, maximum unavailability. | |);

j) desirable restoration time (see § 4.4 of this Recommendation);

k) changed propagation time resulting from restoration over another route (this may be particularly important in the case of data transmission);

l) other functions that might be included in restoration equipment for maintenance purposes.

6.2 *Restoration network planning*

The restoration network should be dimensioned according to the objectives of the restoration capability for faulty transmission systems or equipment, as well as for planned outages.

One example of a method for dimensioning a restoration network without the help of simulation software is to add systematically a certain proportion of restoration links to the normal links.

Another method is to dimension the restoration network for the restoration of certain priority services in case of a single transmission route or transmission link fault. A priority protection for specific services would allow these services to have a better availability. This would allow the planning of a smaller and therefore cheaper restoration network that would be required for a systematic restoration of all transmission routes failures. The restoration network obtained in such a way would not only cost less in investment, but it would also serve to restore non-priority traffic when restoration links are available.

References

[1] CCITT Supplement *Terms and definitions for quality of service, network performance, dependability and trafficability studies* , Fascicle II.3, Supplement No. 6.

[2] CCITT Recommendation *Terms and definitions of teletraffic engineering* , Vol. II, Rec. E.600.

[3] CCITT Recommendation *Vocabulary of switching and signalling terms* , Vol. VI, Rec. Q.9.

[4] CCITT Recommendation *Glossary of terms* , Vol. VI, Rec. Z.341.

[5] CCITT Recommendation *Error performance of an international digital connection forming part of an Integrated Services Digital Network* , Vol. III, Rec. G.821.

Recommendation M.496

FUNCTIONAL ORGANIZATION FOR AUTOMATIC TRANSMISSION | RESTORATION

This Recommendation is a description of the functional organization for three general types of automatic transmission restoration systems:

— 1+1 transmission restoration;

— N+M direct transmission restoration (protection link switching);

— N+M automatic rerouting (protection network switching).

The terminology and general principles of transmission restoration are described in Recommendation M.495. Specifications for equipment of the 1+1 restoration system type can be found in Recommendation G.181 [1]. Specifications for equipment of the N+M direct transmission restoration or automatic rerouting system type can be found in Recommendation G.180 [2].

1 1+1 transmission restoration

1.1 *Purpose of 1+1 transmission restoration*

1.1.1 1 + 1 restoration is used for the restoration of one group or digital block or link on one restoration link that is dedicated to its transmission restoration.

1.1.2 This type of restoration is generally reserved for specific services with a need for a very high availability.

1.1.3 As this method of restoration is rather expensive (duplication of transmission links), it is often effected, at the present time, at low hierarchichal levels (for example, group or primary digital block). This is a preventive protection, adapted to specific services, whereas restoration at the highest order group or digital block is a corrective protection for part of the network.

Figure 3/M.495 illustrates such a configuration.

1.2 *Method of transmission restoration*

1.2.1 The transmission signal is sent on the normal link and generally also on the restoration link at the same time.

1.2.2 In order to ensure the best availability of transmission, it is recommended to have the restoration link routed on a transmission route different from the route of the normal link.

1.2.3 Control equipment or a control function implemented in equipment with other functions, at both ends of the link, ensures link supervision and control and detects the occurrence of such conditions that may need a restoration action. Generally, there is no control circuit in such a transmission restoration system: control and switching can be done at both receive ends of the signal.

When a fault has been detected and confirmed, the switching equipment receives a command for a switching action.

1.2.4 If a switchback function is provided, when the normal link becomes available again for transmission, it is advisable to perform the switchback at a time when there is the least impact on the traffic concerned. At that time, a switching command is sent by the control equipment. The switching equipment switches back the transmission to the normal link.

This switching is normally effected in such a way that it has minimal impact on transmission quality and availability.

1.3 *Restoration time*

Restoration time should be kept as short as possible, in order to have minimal impact on service availability.

2 N+M direct transmission restoration (protection link switching)

2.1 *Purpose of N+M direct transmission restoration*

N+M direct transmission restoration systems provide M restoration links for N normal links. All the links have their terminal equipments located at the same locations.

Figure 1/M.495 illustrates such a configuration.

2.2 *Method of transmission restoration*

2.2.1 The M restoration links may be routed on the same transmission route as all, or part, of the N normal link; but preferably, some restoration links may be routed over a different route, so that a fault of a whole transmission route allows the restoration of some links.

2.2.2 This type of transmission restoration can be effected at all hierarchical levels. It is often used at the transmission system level.

2.2.3 At both ends of the links, control equipment (or a control function implemented in equipment) ensures link supervision and control, and detects the occurrence of a failure. The control circuits for this function might be on a restoration link, or on another link which is not one of the N normal links, or duplicated on at least 2 of the N normal links.

2.2.4 Some of the N normal links might have a higher priority. In this case, when one of them is in fault, it is restored in priority and can use a restoration link on a preemptive basis. This means that:

— in case of a simultaneous fault of several links, and if a complete restoration is not possible, only the highest priority links are restored;

— if all restoration links are in use and if a normal link having a priority higher than the priority of one of the restored links has a failure, the lower priority restored link is interrupted so that the link in fault can be restored.

2.2.5 When a restoration action has been detected, confirmed and accepted (restoration link available or priority link in fault), the switching equipment receives a command for a switching action. Switching might be effected at both ends systematically, but it is also possible to switch only the faulty direction, if necessary.

2.2.6 In the case of automatic switchback, after the normal link is available again for a normal transmission, the control equipment sends a switchback command. In this case, the switching equipment switches back the signal transmitted from the restoration link to the normal link. This switching is normally effected in such a way that it has a minimal impact on transmission quality and availability.

2.3 *Restoration time*

N+M direct transmission restoration is characterized by a requirement to detect a degraded or faulty normal link and switch to a restoration link in a time interval that is short enough not to cause established telephone calls to be released.

2.4 *Other considerations*

2.4.1 A restoration link might be used, when a restoration is not needed, for other purposes such as planned outages or non-priority traffic. In this case, it can be preferable that the N normal links have a preemption of the restoration link when they are in fault.

2.4.2 The maximum number N of normal links for one restoration has to be dimensioned correctly to avoid a too large number of non-restored faults. When a large number of links have to be restored, N+M direct transmission restoration (with M > 1) is necessary; in this case M restoration links can be used for the restoration of N normal ones.

2.4.3 The N+M direct transmission restoration is an automatic system, but it should also allow manual or semi-automatic (remote manual) actions, in order to force switching or inhibit restoration.

3 N+M automatic rerouting (protection network switching)

3.1 *Purpose of N+M automatic rerouting*

N+M automatic rerouting systems provide, on a single switching equipment, M restoration links to N normal ones. The restoration of 1 normal link is effected by a certain number of restoration links that are assembled together.

The restoration systems belong to a restoration network.

Figure 2/M.495 illustrates such a configuration.

3.2 *Method of transmission restoration*

3.2.1 At the present time, this type of restoration is generally effected at high hierarchical levels.

3.2.2 The organization of N+M automatic rerouting systems is generally complex: a network of normal links is protected by a network of restoration links.

There is a supervision and control of every link that can be done by or under the control of one or several restoration control centres. Restoration can be a specific function of a more general control centre.

3.2.3 After a failure is detected on a normal link, the restoration is normally effected according to certain preestablished restoration plans, if the restoration links are available. It is also possible to have a restoration plan computed after failure detection.

A certain number of restoration links are assembled together through switches located at the nodes of the network and connected to the faulty link through switches located at its ends.

3.2.4 It should also be possible to have manual or semi-automatic (remote-manual) action or inhibition of N+M automatic rerouting systems.

3.2.5 If a restoration plan fails or a restoration link used for a restoration has a failure, all restoration links involved in the restoration plan should be released.

3.2.6 After the fault of the normal link is removed, there can be a switchback to the normal link which should have a minimal impact on transmission quality and availability.

3.2.7 Certain equipment, such as automatic digital distribution frames, might have a function of N+M automatic rerouting but might not be dedicated to it.

3.3 *Restoration time*

As the operations of N+M automatic rerouting take network conditions into account, they can involve considerable data processing; they may entail all calls being cleared or lost before the operations are completed. Restoration times can be in the order of seconds, minutes, or even hours, depending on the complexity of the network and its state at that moment.

3.4 *Other considerations*

3.4.1 Restoration links might be used under normal conditions by low-priority traffic. In this case, there is generally a preemption by normal traffic in case of normal link failure.

3.4.2 As the restoration network might not be dimensioned for the total restoration of all transmission route interruptions and multiple failures, it might be necessary to define certain priorities among normal links. In this case, certain links might be restored in priority with preemption of restoration links used by non-priority links.

References

[1] CCITT Recommendation, *Characteristics of 1+1 type restoration systems for use on digital transmission links* , Rec. G.181.

[2] CCITT Recommendation, *Characteristics of N+M type direct transmission restoration systems for use on digital sections, links or equipments* , Rec. G.180.

2.5 Routine maintenance of an international carrier system

Recommendation M.500

ROUTINE MAINTENANCE MEASUREMENTS TO BE MADE ON REGULATED LINE SECTIONS

1 Radio-relay regulated line section

Measurements should be made as indicated below:

1.1 *Regulated line section terminal stations:*

a) daily reading of the line pilot level if necessitated by the type of system. It is preferable that such measurements should always be made at the same time of day;

b) as necessary, readjustment to the nominal value as described in Recommendation M.510.

1.2 *Radio-systems terminals*

1.2.1 At intervals to be determined by agreement between the Administrations concerned, and based on experience of the reliability of the system:

— measurement of the loss/frequency distortion at frequencies in the baseband (additional measuring frequencies) (permissible limits ± | dB);

— when there is no continuous recording of noise, measurement of the total noise level on the noise-measurement channels outside the baseband in accordance with CCIR Recommendation No. 398 [1]. This measurement can be made without causing any interference in the transmission channel.

1.2.2 When the measurement mentioned in § 1.2.1 above gives unacceptably high noise values, or more often, when the reliability of the system makes it desirable, check of the following measurements in accordance with the appropriate CCIR Recommendations for the radio-relay system concerned should be made, the radio-frequency channel being switched to the standby equipment, and the measurement results compared with the results of the reference measurements required by Recommendation M.450, § 3:

— the deviation of the frequency at which the level is unchanged by pre-emphasis;

— the pilot frequency deviation;

— the central position of the intermediate frequency in the non-modulated condition of the system;

— the level of the baseband reference frequency (single frequency check);

— the relative level at the radio reference measurement frequencies (multifrequency check);

— the level of individual interfering signals in the baseband in the non-modulated condition of the system.

Where a protection channel is provided, and if Administrations so desire, noise measurements may be made on that channel with artificial loading, in accordance with CCIR Recommendation 399 [2].

1.2.3 So as to enable the limits for circuit loss variation to be met (see Recommendation M.160), the difference in response between two systems in diversity reception or between a working and standby system should be minimized.

2 Coaxial regulated line section

The following measurements should be made at regulated line section terminal stations:

a) daily reading of the line pilot level if necessitated by the type of system. It is preferable that such measurements should always be made at the same time of day;

b) as necessary, readjustment to the nominal value as described in Recommendation M.510.

The Administrations concerned are left to decide for themselves about measurements at additional measuring frequencies and about checking the operation of the regulators.

Note — Precautions to be taken with additional measuring frequencies:

i) When the end of a regulated line section:

— is not the same as the end of a line link (i.e. when all the groups, supergroups, etc., are through-connected from one regulated line section to another without passing via the through-connection equipment to the basic groups);

— is the same as the end of a line link without complete demodulation to the groups, supergroups or mastergroups (i.e.

when only part of the groups, supergroups, etc., are through-connected direct from one line link to another, without passing via the through-connection equipment to the basic groups);

the maintenance personnel should:

a) avoid sending a measuring frequency that is the same as a pilot frequency of a following regulated line section (unless the pilot frequency on such a following section is protected by a blocking filter at the beginning of the section);

b) take into account the possibility of attenuation to additional measuring frequencies lying at the edges of the frequency band of a through-connected basic group, supergroup, etc., due to the presence of through-connection filters.

ii) Interference between additional measuring frequencies on adjacent coaxial links is possible if precautions are not taken to avoid carrying out simultaneous measurements on adjacent links. For this reason:

a) there should be different dates for routine maintenance measurements on two adjacent links;

b) before making any measurement using an additional measuring frequency, and especially those made when clearing faults, repeater station staff should see to it that measurements are not in progress on an adjacent coaxial link.

3 Symmetric pair regulated line section

The following measurements should be made at regulated line section terminal stations:

a) daily reading of the line pilot level if necessitated by the type of system. It is preferable that such measurements should always be made at the same time of day;

b) as necessary, readjustment to the nominal value as described in Recommendation M.510.

The Administrations concerned are left to decide on measurements at additional measuring frequencies and on checking the operation of the regulators, if applicable. The same applies to any kind of measurement or pilot level reading at intermediate attended or unattended stations.

References

[1] CCIR Recommendation *Measurements of noise in actual traffic over radio-relay systems for telephony using frequency-division multiplex* , Vol. IX, Rec. 398, ITU, Geneva, 1986.

[2] CCIR Recommendation *Measurement of noise using a continuous uniform spectrum signal on frequency-division multiplex telephony radio-relay systems* , Vol. IX, Rec. 399, ITU, Geneva, 1986.

Recommendation M.510

READJUSTMENT TO THE NOMINAL VALUE OF A REGULATED LINE SECTION

(ON A SYMMETRIC PAIR LINE, A COAXIAL LINE OR A RADIO-RELAY LINK)

After the routine measurement or clearance of the fault and when it has been ensured that no faults remain on the system, adjustments should be made as necessary to bring the levels of the line pilots and additional measuring frequencies as close as possible to their nominal value.

Making the whole adjustment in the receiving terminal station should be avoided; adjustments should be made where they are necessary, under the direction of the control or sub-control station concerned.

Methodical readjustment should be carried out when the level measured at the terminal station exceeds the maintenance limits for the carrier system. Due allowance should be made for measuring errors and for random effects which may cause slight short-term variation. The tolerance to be allowed depends on the type of system, its length and the periodicity of the measurements.

For example, the following tolerances may be allowed:

a) in the case of a system with continuous gain control an adjustment should be made only if an improvement of at least 0.3 dB can be obtained;

b) in the case of a system with step-by-step gain control allow a permissible tolerance of ± (one-half the gain control step ± | .3 dB).

Recommendation M.520

ROUTINE MAINTENANCE ON INTERNATIONAL GROUP,

SUPERGROUP, ETC., LINKS

1 Type of routine tests

Only measurements of the pilot level are made on international group, supergroup, etc. links. These do not involve other stations. Therefore, Administrations are free to decide on the methods and periodicities. In order to ensure that the performance limits of the links laid down in Recommendation M.160 are met, the following tests are recommended for consideration.

2 Links without an automatic regulator

At control stations routine measurements should be made of the pilot level. The periodicity of these routines may be weekly or monthly depending on the complexity of the routing and constitution of the link.

3 Links with an automatic regulator

At control stations where a regulator is installed, the level at the input and output of the regulator, if these measurement points are provided by the equipment, may be measured every six months.

4 Continuous recording of pilot level

In addition to the above it is useful to be able to take continuous pilot-recordings as required to detect fault conditions which do not trigger the normal alarm systems.

Recommendation M.525

AUTOMATIC MAINTENANCE PROCEDURES FOR INTERNATIONAL

GROUP, SUPERGROUP, ETC., LINKS

1 General

In order to reduce corrective maintenance and minimize preventive maintenance in accordance with Recommendation M.20 the routine measurements of group, supergroup, etc. links may be carried out by automatic measurements without interruption.

Such routine measurements, where provided, should be for the same characteristics given in Recommendation M.460, e.g. overall loss, random noise, etc.

The decision to use automatic measurement procedures and the determination of intervals between routine measurements are matters for agreement by the concerned Administrations.

The need for readjustment based on the results of these measurements should be determined according to Recommendation M.530.

2 Frequencies and levels of test signals

The recommended frequencies for overall loss measurement are given in Table 1/M.525. The maintenance measurements can be made at some or all of those frequencies.

The test frequencies for group, supergroup, etc. links are chosen to fall between channels , groups, supergroups, etc. These frequencies are shifted at ± | 0 Hz with respect to 4 kHz multiplied frequencies to avoid carrier leaks and other spurious tones interference. The automatic measurement equipment usually makes use of pre-defined software and/or hardware.

Test frequencies for supermastergroups are not shifted at ± | 0 Hz, as they are located in wide guard intervals and do not coincide with carrier leaks and pilot frequencies.

Test frequencies 9008 kHz, 11 | 96 kHz and 11 | 48 kHz given in Recommendation M.460 should be shifted to avoid interferences between supermastergroup and mastergroup No. 7 and No. 9 pilot frequencies (see Recommendation M.350).

Test signal levels should generally not exceed —20 dBm0. A level of —10 dBm0 may be used for master and supermastergroup measurements. When the measurement of Group No. 3 (see Recommendation M.330) is being made, the test signal at 103.92 kHz has to be blocked, otherwide it is necessary to make the correction for the loss at the frequency 103.92 kHz, caused by the 411.86 kHz reject filter.

H.T. [T1.525]

TABLE 1/M.525

Frequencies of test signals

Type of link	Frequencies (kHz)
Supermaster group 8516.3*, 8760, 9004, 9256, 9504, 9792, 10 | 80, 10 | 24, 10 | 76, 10 | 24, 11 | 50, 11 | 00, 11 | 44, 11 | 96, 12 | 44, 12 | 87.4* }	{
Master group 812.6*, 871.92, 931.92, 1055.92, 1179.92, 1303.92, 1427.92, 1555.92, 1675.92, 1799.92, 1923.92, 1983.92, 2043.7* }	{
Supergroup (4 kHz channels) 312.3*, 320.08, 328.08, 344.08, 360.08, 376.08, 392.08, 408.08, 432.08, 456.08, 472.08, 488.08, 504.08, 520.08, 536.08, 544.08, 551.4* }	{
Group (4 kHz channels) 60.6*, 63.92, 67.92, 71.92, 75.92, 79.92, 83.92, 87.92, 91.92, 95.92, 99.92, 103.92, 107.7* }	{

Note — As a rule the frequencies marked by an asterisk (*) cannot be used for measurements without traffic interruption. These frequencies may be used in the absence of traffic in the edge channels or a low level of test signal (below —45 dBm0).

Table 1/M.525 [T1.525], p.

Recommendation M.530

READJUSTMENT TO THE NOMINAL VALUE OF AN

INTERNATIONAL GROUP, SUPERGROUP, ETC., LINK

1 General

Before any adjustment is made to a link it must first be ensured that each regulated line section or higher-order link over which the link concerned is routed is correctly adjusted and that the level of the reference pilot at the transmitting end is correct. No readjustments will be made on the link except under the direction of the control station, after consideration of measurement results.

2 Links without a regulator

2.1 For links which use only one regulated line section, or one higher-order link, readjustment of levels to values as close as possible to their nominal value must be made systematically after any measurement or clearance of a fault. Any departure in excess of ± | dB from the original

line-up at the time the link was first established must be investigated to ensure that there is no fault.

2.2 For links of more complex constitution, no readjustment need be made until the departure from the nominal value exceeds 0.5 dB (see the Note in § 3 of this Recommendation). When the departure from the nominal value exceeds these limits, adjustment to a value as near as possible to the nominal value should be carried out. Adjustment at the terminal station only is permissible within the limits of departure from the settings at the time of the previous reference measurements as a function of the distance to the origin of the link or to the nearest upstream automatic regulator, as given in Table 1/M.530.

H.T. [T1.530]

TABLE 1/M.530

{ Distance to origin or regulator } Limit for departure from the settings noted for previous reference measurements beyond which the possibility of a fault should be investigated (see the note in § 3 of this Recommendation) }	{
Up to 1000 km	± | dB
1000-2000 km	± | dB
Above 2000 km	± | dB

TABLE [T1.530], p.

If, for the distance concerned, adjustment at the terminal station would cause departures greater than those permitted by the table, measurements should be made at all through-connection points to find if a fault exists. If a fault exists, it should be located and cleared. If no fault exists, but the

change is due to normal causes, e.g. temperature changes, aging, etc., adjustments should be made at each through-connection point to bring the level of the reference pilot as near as possible to its nominal value before making a final adjustment at the terminal station.

3 Links with a regulator

No readjustment need be made until the departure from the nominal value measured at the input to the regulator exceeds ± | dB. Any departure in excess of ± | dB from the nominal value measured at this point must be investigated.

Note — In determining the margins within which equipment should be readjusted, it has been found useful to distinguish three ranges about the nominal value into which the received level might fall:

— a relatively small range in which no action need be taken. This enables the staff to avoid waste of time in continually readjusting in order to compensate minor changes;

— a somewhat larger range in which the received level may be readjusted to as near the nominal value as possible by the terminal station, without having to ask intermediate stations to measure and/or readjust. (This is subject to the overriding proviso that the cumulative adjustment made at the terminal station must not exceed a certain amount relative to the settings noted when the last set of reference measurements was made);

— a range in which it must be assumed that a fault may exist which must be sought and cleared before any readjustment is permitted. After the fault (if any) has been found and all stations, intermediate and terminal, have, if necessary, readjusted their levels to as near the nominal value as possible, the new settings are noted for future reference purposes when making subsequent adjustments.

The three ranges are shown in Figure 1/M.530 in relation to a typical distribution of level values.

A suitable value for *y* in Figure 1/M.530 is considered to be 2 *S* , where *S* is the observed standard deviation. This concept is the basis of Table 1/M.530.

FIGURE 1/M.530 p.

Recommendation M.535

SPECIAL MAINTENANCE PROCEDURES FOR MULTIPLE DESTINATION, UNIDIRECTIONAL (MU) GROUP AND SUPERGROUP LINKS

The Recommendations covering the maintenance of groups and supergroups will apply as far as possible but there will be a number of new maintenance problems which are peculiar to multiple destination links. In particular, arrangements will be needed to check the performance of the MU main section of such links. In order to simplify the procedures and minimize interference to other users of the common path, it is recommended that the send reference station (see Figure 1/M.460) for the MU main section should act as a focal point for reports and inquiries concerning the MU main section. The group, supergroup, etc., control stations will still be responsible for localizing a fault to a particular section of a link in accordance with Recommendation M.130.

When a fault is found to be in the communication satellite link, the send reference station will report the fault to the satellite control responsible for this link from baseband-in to baseband-out. When the fault is cleared, the send reference station will advise the MU main section controls which will in turn advise the group, supergroup, etc., controls concerned.

Recommendation M.540

ROUTINE MAINTENANCE OF CARRIER AND PILOT GENERATING EQUIPMENT

1 If a country has a national frequency standard , it is desirable to use it for checking the frequency of the master oscillators of carrier systems accuracy for various carrier systems.) This frequency standard can be guaranteed to about 1 part in 10^8 by means of the three-way frequency comparisons organized by the CCIR. However, we must note that a larger accuracy can be obtained in the countries that will use an atomic frequency standard (for example cesium or rubidium).

2 If a country has no national frequency standard, there are two possibilities:

a) to receive by radio the standard signals transmitted in accordance with CCIR Recommendations;

b) to receive from a neighbouring country, over a metallic circuit, a frequency derived from the national standard of that country.

It may be necessary in some cases to make a direct comparison of the frequency of the master oscillators of the carrier systems of different countries; this comparison will be effected by means of the frequency comparison pilots.

3 The changeover of master oscillators may cause a short interruption of a few milliseconds and a sudden phase-change. Because the effect of these interruptions and phase-changes is felt throughout the carrier system, changeover of master oscillators should be made only when absolutely necessary.

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H.T. [1T1.540]

TABLE 1/M.540

Table showing the recommended frequency accuracy for reference pilots, carriers, etc., in various carrier systems

System	Frequency and accuracy	
	Reference pilot	Carrier generator
(1)	(2)	(3)
(1 + 3) open-wire	16.110 kHz 31.110 kHz	2.5 × 10DlF2615 | 2.5 × 10DlF2615
8 circuit open-wire		10DlF2615
12 circuit open-wire	5 × 10DlF2616	5 × 10DlF2616
Symmetric pair 1, 2, 3, 4 or 5 groups	Line regulating | 60 kHz Auxiliary	± | Hz ± | Hz
2 supergroups Line regulating | 60 kHz | 56 kHz }	{ ± | Hz ± | Hz 2.6 MHz	Line regulating 2 | 04 kHz . ± | 0 Hz

2, 4 MHz {

Line regulating
| 60 kHz
| 08 kHz
4 | 92 kHz
Auxiliary
2 | 92 kHz
}

{

.
± | 1 Hz
± | 3 Hz
± | 0 Hz
.
± | 5 Hz
}

{

Additional measuring
frequencies (all)
}

± | 0 Hz

Coaxial pair 2.6/9.5 mm {

, 60 MHz {

Line regulating

4 | 87 kHz
12 | 35 kHz
22 | 72 kHz
40 | 20 kHz
61 | 60 kHz
}
± | $\times 10^{D}$lF261^{5}
}
 	
Additional measuring frequencies (all)
}
± | $\times 10^{D}$lF261^{5}
}
 	
{
	{
	
	{
		{	

Tableau 1/M.540 [1T1.540], p. 14

H.T. [2T1.540]
TABLE 1/M.540 | fI(cont.)

System	Frequency and accuracy Reference pilot	 Carrier generator
(1)	(2)	(3)
12 + 12 60 kHz Others by agreement between Administrations } Error in reconstituted frequency over a 140 km section and not to exceed 0.3 Hz (provisional value) }	{ ± | Hz	{
6 MHz Video carrier 1056 kHz ± 5 Hz }		{
12 MHz Video carrier 6799 kHz ± 100 Hz }		{

4 kHz spacing
{
Basic group B
and
Basic supergroup
}
84.080 kHz **and**
104.080 kHz
411.920 kHz and 547.920 kHz
84.140 kHz and 411.860 kHz
}
.
± | Hz
± | Hz
}
	{
	
	{	

{
Basic mastergroup and
15-supergroup assembly
}
1 | 52 kHz **and 547.920 kHz**
}
	{
	
	± | Hz	

Basic supermastergroup 11 | 96 kHz **and 547.920 kHz** }	{ ± | 0 Hz	
3 kHz spacing 84 kHz (or other frequency by agreement) }	{ ± | Hz	

{
Basic group and
Basic supergroup
}
a) **| 52 kHz and 547.920 kHz**
}
	{	

Tableau 1/M.540 fin [2T1.540], p. 15

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2.6 **Bringing into service and maintenance of international digital transmission systems**

Recommendation M.550

PERFORMANCE LIMITS FOR BRINGING INTO SERVICE AND MAINTENANCE OF DIGITAL PATHS, SECTIONS, AND LINE SECTIONS

1 General

The purpose of this Recommendation is to provide limits for bringing into service, and limits for maintenance of digital paths, sections, and line sections in order to achieve the performance objectives given for ISDN in the Series G Recommendations. These objectives include error performance (Rec. G.821 [1]), slips (Rec. G.822 [2]), jitter and wander (Rec. G.823 [3] and Rec. G.824 [4]), and availability. This Recommendation presently only contains

limits for error performance. The other limits are under study. This Recommendation describes the parameters to be mesured and the measurement techniques to be employed to meet the principles given in Recommendations M.20, M.32 and M.34.

The methods and procedures for applying these limits are described in Recommendation M.555 for the bringing into service procedures.

Since the performance limits are intended to satisfy the needs of the future digital network, it must be recognized that such limits cannot be readily achieved by all of today’s digital equipment and systems. Nonetheless, it is intended that there will be a single set of limits that applies to all technologies.

It is desirable to do in-service, continuous measurements. In some cases e.g. for bringing into service, out-of-service measurements may be necessary.

This Recommendation covers all digital paths, sections, and line sections which operate at 64 kbit/s and higher, including the ISDN subscriber access described in Recommendation I.412 [5], and the network digital hierarchy described in Recommendation G.702 [6].

There is a need to reduce measured data to that which is essential and relevant to maintenance staff.

2 Allocation of objectives

Digital error performance objectives on which this Recommendation is based are given in Recommendation G.821 [1] for an end-to-end 64 kbit/s hypothetical reference connection (HRX) defined in Recommendation G.801 [7]. These objectives are further allocated in Recommendation G.821 [1] to local, medium, and high grade parts of the connection. However, maintenance limits are needed for smaller entities. Hence, a further allocation is necessary, so that limits can be developed for digital paths, digital sections, and digital line sections, as these are defined in Recommendation M.300. Following are described the reference models to be used when allocating the digital performance objectives on which bringing into service and maintenance limits will be based.

2.1 *Reference models*

The HRX of Recommendation G.801 [7] and the circuit quality demarcation of Recommendation G.821 [1] are shown combined in Figure 1/M.550.

The error performance objectives for this 64 kbit/s connection are given in Table 1/M.550.

Half of the overall severely errored seconds, (SES) objective of 0.2% is reserved as a block allocation to accommodate adverse network conditions (e.g. for digital radio systems) so the values in Table 2/M.550 apply to the remaining 0.1% SES. These overall objectives are further allocated to the circuit quality classifications of the HRX as shown in Table 2/M.550.

For Recommendation G.921 [8], a further allocation of objectives to hypothetical reference digital sections (HRDS) based on the 2.048 Mbit/s hierarchy is shown in Table 3/M.550. An HRDS is a digital line section in the terminology of Recommendation M.300.

Figure 1/M.550, p. 16

H.T. [T1.550]
TABLE 1/M.550
Error performance objectives

Performance classification	Objective (maximum % of time)
Degraded minutes (DM)	10**.**
{ Severely errored seconds (SES) }	0.2
Errored seconds (ES)	8**.**

Tableau 1/M.550 [T1.550], p. 17

H.T. [T2.550]
TABLE 2/M.550
Allocation of objectives

{ HRX circuit quality classification }	Percentage of objective
Local (each end)	15
Medium (each end)	15
High	40

Tableau 2/M.550 [T2.550], p. 18

H.T. [T3.550]
TABLE 3/M.550
Digital line section quality classificaton for error performance

Section quality class	HRDS length (km)	Allocation (%)	For circuit class
1	280	0.45	High or medium
2	280	2**.45**	Medium
3	50	2**.45**	Medium
4	50	5**.45**	Medium

Tableau 3/M.550 [T3.550], p. 19

The allocation is a percentage of the overall objective for the HRX for Errored Seconds (ES), SES, and Degrated Minutes (DM). For shorter sections, there is no reduction in the allocation. For a longer section, its overall allocation should correspond to that of an integer number of HRDSs, the combined length of which is at least as long as the real section.

These figures and tables are simplified versions of those in Recommendations G.801 [7], G.821 [1], and G.921 [8]. For a full explanation, the original figures and tables, along with their footnotes, should be consulted.

The comparable allocations for the 1.5 Mbit/s hierarchy is under study in Recommendation G.911 [9].

2.2 *Allocation principles to be employed*

For this Recommendation, the allocation of the error performance objectives for each digital path, digital section and digital line section, as defined in Recommendation M.300, must be determined. This will be based on the allocation for the different parts of the HRX as defined in Recommendation G.821 [1], and on the allocations for digital line sections as defined in Recommendations G.911 [9] and G.921 [8].

The allocation principles for satellites are for further study, taking into account Recommendation G.821 [1].

The significant performance degradation of radio-relay systems tend to be concentrated into a few days or even hours (those times with severe fading). For this reason, a direct linear derivation of performance limits for shorter time periods from Recommendation G.821 [1] monthly performance objectives may not be suitable for digital sections containing radio-relay systems.

The effect of fluctuations that occur in radio-relay system performance, as well as to a lesser degree in other transmission media, requires further study to set appropriate bringing into service limits, maintenance limits and test durations.

2.2.1 *Allocation principles for sections*

The objectives to be used for digital line sections can be taken directly from Recommendations G.911 [9] and G.921 [8].

However, digital sections and digital paths are achieved by interconnections of digital line sections and multiplexing equipment at various hierarchical levels (8, 34, 45, 140 Mbit/s).

The performance allocation for digital sections is the sum of the allocations of the digital line sections from which the digital section is derived.

2.2.2 *Allocation principles for digital paths*

The allocation principles for the paths differ for bringing into service and for maintenance.

For bringing into service, the allocation is the same as that for digital sections, namely the sum of the allocations of the digital line sections from which the path is derived. This results in an allocation based on the real physical configuration of the path. If the performance objective for a path is denoted A, then:

$$A = \sum_j N_j \mid (\text{mu} \mid \text{fIQ}_j$$

where

N_j Number of digital line sections of quality class j,

Q_j Allocation for a digital line section of quality class j.

For maintenance allocation, to minimize the number of thresholds that must be monitored in the exchange, a different objective is used, namely the maximum allowed allocation for the type of path. This allocation is determined by the class of exchange at each end of the path. The allocation principle is illustrated by the following example.

If the nominal section of Figure 1/M.550 is made up of the 1250 km medium grade allocation, the medium grade path allocations can be defined as:

A = Allocation for path LE-PC (local exchange-primary centre)

B = Allocation for path PC-SC (primary centre-secondary centre)

C = Allocation for path SC-TC (primary centre-tertiary centre)

D = Allocation for path TC-ISC (tertiary centre-international switching centre)

Further, let

W_i = Number of digital sections of class 1 (allocation 0.45%)

X_i = Number of digital sections of class 2 (allocation 2%)

Y_i = Number of digital sections of class 3 (allocation 2%)

Z_i = Number of digital sections of class 4 (allocation 5%)

where subscript i | denotes the paths LE-PC (denoted as a), PC-SC (denoted as b), etc. with allocations A, B, etc., as defined above.

To meet the Recommendation G.821 [1] objectives, each Administration must jointly determine A to D and W_i to Z_i based on its transmission plan and on its network design in order to meet the equations below:

$A + B + C + D$ 15%

$A \geq$" $0.45\, W_a + 2.0\, X_a + 2.0\, Y_a + 5.0\, Z_a$

$B \geq$" $0.45\, W_b + 2.0\, X_b + 2.0\, Y_b + 5.0\, Z_b$

$C \geq$" $0.45\, W_c + 2.0\, X_c + 2.0\, Y_c + 5.0\, Z_c$

$D \geq$" $0.45\, W_d + 2.0\, X_d + 2.0\, Y_d + 5.0\, Z_d$

For example, if the paths between the LE and PC in this Administration's network in the worst case are made up of two line sections of class 2 and one of class 3, then A must be $2 \times 2\% + 1 \times 2\% = 6\%$. Thus, $B + C + D$ must be 9%. Similarly, values of B | to D can be selected.

3 Relationship between performance limits and objectives

3.1 *Relationship between short-term limits and long-term objectives*

The limits in this Recommendation are to be used to indicate the need for actions during the phases of maintenance and bringing into service. These procedures are intended to result in network performance which meets the performance objectives of the relevant Series G Recommendations. The particular parameters measured, the measurement duration, and the limits used for the procedure need not be identical to those used for specifying the performance objectives as long as they result in network performance which meets these objectives. For example, the error performance objectives refer to long periods, such as one month. However, practical considerations demand that maintenance and bringing-into-service limits be based on shorter measurement intervals.

Statistical fluctuations in the occurrence of anomalous events in time means that one cannot be certain that the long-term objectives are met. The limits on the numbers of events and the duration of measurements must be set to ensure that passing the tests will predict, with an acceptable level of confidence, that the long-term objectives will be met. The limits and durations given as examples below were arrived at after comparing limits derived from statistical theory to empirically observed network performance.

3.2 *Types of limits*

Limits are needed for several maintenance functions as defined in Recommendation M.20. This Recommendation provides limits for three of these functions: bringing into service, keeping the network operational (called maintenance here) and system restoration. Limits for commissioning (installation and acceptance testing) are not provided in CCITT Recommendations.

Bringing-into-service tests are rigorously done by measuring using a quasi-random signal source (QRSS) between digital junction interfaces. Due to the statistical character of the degradation in digital networks, these measurements should be long-term measurements. This applies to new equipment or routes. However, for practical reasons (a new path on a route with many paths already in-service, rearrangements of the network, etc.) the measurements between junctions may be reduced to a quick measurement and the supervision completed with performance monitoring equipment.

Two limits are provided for use in bringing-into-service testing. If performance is better than the first limit, the entity can be brought into service without doubt. If performance is between the two limits, further testing is necessary. Corrective action is required if performance is worse than the second limit. The definition of the limits are a function of a given allocation and of the measurement duration and will be based on a predictive model under study. These limits depend on Recommendation G.821 [1] parameters for a given bit rate.

Once entities have been placed into service, supervision of the network requires additional limits, as described in Recommendation M.20. This supervision is done on an in-service basis using performance monitoring equipment. The supervision process involves analyzing anomalies and defects detected by maintenance entities to determine if the performance level is normal, degraded, or unacceptable. Thus, degraded and unacceptable performance limits are required. In addition, a limit on performance after intervention (repair) is also required. It may be different than the bringing-into-service limit.

3.2.1 *Reference performance objectives*

The reference performance objectives are defined as the performance objectives for ES, SES, and DM directly derived from Recommendations G.821 [1], G.911 [9] and G.921 [8] using recommended allocations and from the additional allocations described above in § 2 for digital paths, sections and line sections.

Reference performance objectives are calculated on a long-term basis (one month is suggested). These form the basis from which limits for bringing into service and maintenance are set.

3.2.2 *Bringing-into-service limits*

The aging margin is the difference between the reference performance objective and the bringing-into-service limit. This margin should be as large as possible to minimize maintenance interventions.

This margin for digital line sections will depend on the procedures of individual Administrations. A stringent limit which is 10 times better than the reference performance objective and a measuring period of a few days should be used when previous commissioning tests have not been conducted.

When previous commissioning tests have been carried out, the out-of-service test for bringing into service can be conducted for a shorter period and does not require the same stringent limits.

Continuous in-service monitoring is required to provide sufficient confidence in the long-term performance. (Typically, commissioning tests have durations of several days and have more stringent limits than bringing-into-service tests).

The ageing margin for digital sections and paths is on the order of two times better than the reference performance objective. The testing duration will obviously be limited to no more than a few days.

All of these bringing-into-service limits and durations are for further study.

Two limits can be calculated:

— S1, a limit corresponding to a number of events (ES, SES, DM) under which the entity can be brought into service without any doubt;

— S2, a limit corresponding to a number of events above which it is necessary to improve the performance of the entity under test.

For an observed number of events between the values of S1 and S2 the entity may be conditionally be brought into service. It then becomes necessary to monitor the evolution of its performance during a longer period of time. This monitoring can be performed using the TMN surveillance capability. The value of S1 is equal to the bringing-into-service limit described above. The value of S2 can be derived from S1 using a statistical coefficient under study.

3.2.3 *Maintenance limits*

3.2.3.1 *Unacceptable performance limits*

This performance level is defined in Recommendation M.20 (§ 5.1.3).

The unacceptable performance limit for a given entity is at least 10 times worse than the reference performance objective. The monitoring duration is between 15 minutes and one hour.

3.2.3.2 *Degraded performance limits*

This performance level is defined in Recommendation M.20 (§ 5.1.3).

The degraded performance limit for a given entity is on the order of two times better for line sections and 1.3 times better for paths and sections than the reference performance objective. The monitoring duration may be a fixed duration that depends on the rate in the digital hierarchy.

3.2.3.3 *Performance limit after intervention (repair)*

This performance limit is on the order of eight times better than the reference preformance objective for digital line sections and the same as the bringing-into-service limit for digital paths and sections (see Recommendations M.35 and M.555).

3.2.4 *System restoration limits*

The ‘‘restoration indication signal’’ is used to control sytem restoration (under study).

3.3 *Performance limits*

Performance limits are defined for Recommendation G.821 [1] parameters (ES, SES, DM). It is obvious that each performance limit will have its own threshold and will require its own measurement duration. Examples of the above principles and limits are shown in Figure 2/M.550.

3.4 *Translation of performance measurements*

Translation of performance measurements at primary rate and above, to error performance parameters at 64 kbit/s will follow the rules in Annex D of Recommendation G.821 [1].

3.5 *Use of thresholds*

The general strategy for the use of performance monitoring information and thresholds is described in Recommendation M.34. It is expected that these thresholds and information will be reported to operations systems via the TMN for both real time and longer term analysis. When thresholds of unacceptable or degraded performance level are reached [e.g. prompt maintenance alarm (PMA) or deferred maintenance alarm (DMA)], maintenance action should be initiated independently of the performance measurement. Other thresholds may be used for maintenance and longer term quality analysis. The operations systems will use real time processing to assign maintenance priorities to these thresholds and information, using the performance supervision process described in Recommendation M.20.

Figure 2/M.550, p.

4 Parameters for performance limits

The basic performance parameters to be estimated are ES, SES, and DM as defined in Recommendation G.821 [1]. This allows measurement of the unavailability of digital paths, sections, and line sections and of their performance. These parameters are measured using the concepts of anomalies and defects defined in Recommendation M.20 as shown in Figure 3/M.550.

4.1 *Basic performance parameters*

The basic performance parameters are the following:

— *Errored seconds (ES)*

An errored second is a second with at least one anomaly or defect.

— *Severely errored seconds (SES)*

A severely errored second is a second with a binary error ratio (BER) [as can be measured using a quasi-random signal source (QRSS)] greater than or equal to 10^{D}lF261^{3} or at least one defect (except slips).

A pseudo-severely errored second is a second with at least N1 anomalies (when the anomaly is not a binary error, i.e. when it is an error indicator such as a code violation, CRC error, etc.) or one defect (except slips). The value of N1 is an estimator defined to correspond to a BER of 10^{D}lF261^{3} in one second. N1 is a function of the accuracy and efficiency of the anomaly detectors.

— *Degraded minutes (DM)*

A degraded minute is a group of 60 consecutive seconds, after excluding SES, with a BER of 10^{D}lF261^{6} or worse.

A pseudo-degraded minute is a group of 60 consecutive seconds, after excluding SES, with at least N2 anomalies or at least one slip (when the anomaly is not a binary error). N2 is calculated similarly to N1, to detect a BER of 10^{D}lF261^{6} in one minute.

Two techniques used to make these measurements are QRSS and performance monitoring.

Figure 3/M.550, p.

4.2 *Measurements using a QRSS*

When a QRSS is used to measure the basic performance for bringing into service or maintenance, the anomalies and defects detected by the measuring equipment are defined below.

4.2.1 *Anomalies*

Bit errors are the only types of anomalies detected by a QRSS measurement.

4.2.2 *Defects*

Loss of signal and loss of synchronization are the types of defects detected by a QRSS measurement.

4.3 *Measurements using performance monitoring*

When performance monitoring is used to estimate the basic performance parameters for maintenance, the anomalies and defects detected by network elements (NEs) are defined below. DM may be calculated in NEs or in an operations system.

4.3.1 *Anomalies*

Anomalies detected by NEs include the following:

a) Bit error indicators:

— code violations,

— CRC errors,

— frame alignment signal errors,

— block parity errors.

b) Loss of signal energy (possibly brief).

The probability of error detection must be specified for both Poisson and bursty error models. The efficiency (detected errors/actual errors) of the information generated will be taken into account in the establishment of the basic performance parameters.

4.3.2 *Defects*

Defects include the following parameters generated by the equipment:

— loss of frame alignment (or loss of synchronisation);

— loss of signal;

— alarm indication signal (AIS);

— alarm information to the remote end;

— slips;

— restoration indication signal (under study).

Loss of frame alignment is defined in G.704 [10] and AIS and alarm information to the remote end are defined in Recommendation M.20, § 5.4. A string of N_i zeros at bit rate i will be considered a loss of signal. The value of N_i is for further study.

Further study is needed to relate these anomalies to the performance parameters specified in Recommendation G.821 [1], taking into account error distributions, e.g. Poisson and bursty, and algorithms for estimating performance parameter values from observed anomalies. This study needs to be coordinated with Working Party IV/2 and with Study Groups XV and XVIII.

5 Performance limits

Performance limits are expressed by the number of events in the specified time interval, not by the percent of time.

The tables are entered using the percent allocation of the overall objective that applies to the entity in question. These reference performance objectives are defined in § 2. They are calculated as follows:

$$\text{Reference performance objective} = \text{duration} \times \text{allocation} \times \text{objective}$$

6 Bringing-into-service and maintenance limits for digital line sections

The particular allocations given in Tables 4/M.550 and 5/M.550 are for the 2 Mbit/s hierarchy. No similar allocations exist for the 1.5 Mbit/s hierarchy.

The duration of the test indicated in the tables is for example only and requires further study. It should be noted that some Administrations use one duration (e.g. on the order of days) for the test of the first digital section in a block and a shorter duration (e.g. on the order of hours) for the remaining sections in that block that are brought into service within a few weeks. The possibility of using shorter test durations in those cases when in-service performance monitoring will be used following the bringing-into-service test is an area for further study.

H.T. [T4.550]

TABLE 4/M.550

Bringing-into-service limits for 64 kbit/s digital line sections

| ua)

Allocation (%)	{								
	S1 limit Events/4 days ES	S2 limit Events/4 days SES	DM	ES	SES	DM	ES	SES	DM
0.45	124	2	3	12	0	0	—	—	—
2.0	553	7	12	55	1	1	For further study		
5.0	1382	17	29	138	2	3	—	—	—

a) The bit rate translation rules of Annex D of Recommendation G.821 | 1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note — The values in this table are for example only.

Table 4/M.550 [T4.550], p.

H.T. [T5.550]

TABLE 5/M.550

Maintenance limits for 64 kbit/s digital line sections

| ua)

Allocation (%)	{								
	{ { ES	SES	DM	ES	SES	DM	ES	SES	DM
0.45	31	0	1	—	—	—	—	—	—
2.0	138	2	3	For further study	For further study				
5.0	346	4	7	—	—	—	—	—	—

a) The bit rate translation rules of Annex D of Recommendation G.821 | 1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note — The values in this table are for example only.

Table 5/M.550 [T5.550], p.

6.1 *Performance limits for digital line sections at other rates*

Performance limits for digital line sections at other rates, e.g. 1.5, 2, 6, 8, 32, 45, 97 and 140 Mbit/s are for further study.

7 Bringing-into-service and maintenance limits for digital sections

The limits are shown in Tables 6/M.550 and 7/M.550.

The duration of the test indicated in the tables is for example only and requires further study. It should be noted that some Administrations use one duration (e.g. on the order of days) for the test of the first digital section in a block and a shorter duration (e.g. on the order of hours) for the remaining sections in that block that are brought into service within a few weeks. The possibility of using shorter test durations in those cases when in-service performance monitoring will be used following the bringing-into-service test is an area for further study.

H.T. [T6.550]
TABLE 6/M.550
Bringing-into-service limits for 64 kbit/s digital paths and sections
| ua)

Allocation (%)	{								
	S1 limit Events/3 days ES	S2 limit Events/3 days SES	DM	ES	SES	DM	ES	SES	DM
1	207	3	4	104	1	2	—	—	—
2	415	5	9	207	3	4	—	—	—
3	622	8	13	311	4	6	For further study		
4	829	10	17	415	5	9	—	—	—
5	1037	13	22	518	6	11	—	—	—
6	1244	16	26	622	8	13	—	—	—

a) The bit rate translation rules of Annex D of Recommendation G.821 | 1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note — The values in this table are for example only.

Table 6/M.550 [T6.550], p.

H.T. [T7.550]
TABLE 7/M.550
Maintenance limits for 64 kbit/s digital sections
| ua)

Allocation (%)	{ { {								
	ES	SES	DM	ES	SES	DM	ES	SES	DM
1	69	1	1	—	—	—	—	—	—
2	138	2	3	—	—	—	—	—	—
3	207	3	4	For further study	For further study				
4	276	4	6	—	—	—	—	—	—
5	346	4	7	—	—	—	—	—	—
6	415	5	8	—	—	—	—	—	—

a) The bit rate translation rules of Annex D of Recommendation G.821 | 1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note — The values in this table are for example only.

Table 7/M.550 [T7.550], p.

7.1 *Performance limits for digital sections at other rates*

Performance limits for digital sections at other rates, e.g. 1.5, 2, 6, 8, 32, 34, 45, 97 and 140 Mbit/s are for further study.

8 Bringing-into-service and maintenance limits for digital paths

Bringing-into-service limits for digital paths are the same as those for digital sections, as shown in Table 6/M.550. The maintenance limits are given in Table 8/M.550.

H.T. [T8.550]

TABLE 8/M.550

Maintenance limits for 64 kbit/s digital paths

| ua)

Allocation (%)	{ { ES	{ SES	DM	ES	SES	DM	ES	SES	DM
2.5	173	2	4	—	—	—	—	—	—
3.5	242	3	5	—	—	—	—	—	—
4,	276	4	6	For further study	For further study				
5.5	380	5	8	—	—	—	—	—	—
6.	415	5	9	—	—	—	—	—	—

a) The bit rate translation rules of Annex D of Recommendation G.821 | 1] must be applied to the measurements made at the entity rate in order to establish a comparison with the limits outlined in this table.

Note — The values in this table are for example only.

Table 8/M.550 [T8.550], p.

8.1 *Performance limits for digital paths at other rates*

Performance limits for digital paths at other rates, e.g. 1.5, 2, 6, 8, 32, 34, 45, 97 and 140 Mbit/s are for further study.

ANNEX A

(to Recommendation M.550)

Example performance limits

A.1 *Calculation of performance limits*

The values in the following tables are for example only.

The reference performance objectives are calculated as specified in § 5. For example, the first three numbers in Table 4/M.550 are calculated as follows:

Number of ES $= 4 \text{ days} \times 24 \times 60 \times 60 \times 0.0045 \times 0.08 = 124$

Number of SES $= 4 \text{ days} \times 24 \times 60 \times 60 \times 0.0045 \times 0.001 = 2$

Number of DM $= 4 \text{ days} \times 24 \times 60 \times 0.0045 \times 0.10 = 3$

The value of S1 is calculated as specified in § 3.2.2. For example, the first three values in Table 4/M.550 are calculated as follows:

Number of ES = 0.1 × Reference performance objective = 12

Number of SES = 0.1 × Reference performance objective = 0.16 | (= |

Number of DM = 0.1 × Reference performance objective = 0.26 | (= |

The value of S2 is calculated from S1 by applying a statistical parameter.

The values for unacceptable and degraded performance limits are calculated from the values specified in §§ 3.2.3.1 and 3.2.3.2 and include confidence limit in addition.

It is expected that the maintenance limits will be used as thresholds for continuous in-service performance monitoring. One crossing of these thresholds (e.g. after exceeding the limits specified in Table A-2/M.550 for 24 hours) would not necessarily generate information requiring human response. Rather, as noted in the footnote to Figure 2/M.550, it would be an input to the alarm information process, which would collect inputs until a representative value has been reached (which may occur over several days) and then process such values and generate alarm information requiring human response at the apropriate time.

A.2 *Example of bringing-into-service and maintenance limits for digital line sections*

The values of Tables A-1/M.550 and A-2/M.550 are measured at the rate of the digital sections and referred to the 64 kbit/s rate using Annex D of Recommendation G.821 [1].

H.T. [T9.550]

TABLE A-1/M.550

Example of bringing-into-service limits for 64 kbit/s digital line sections

Allocation (%)	{								
	S1 limit Events/4 days ES	S2 limit Events/4 days SES	DM	ES	SES	DM	ES	SES	DM
0.45	124	2	3	12	0	0	25	1	1
2.0	553	7	12	55	1	1	75	2	2
5.0	1382	17	29	138	2	3	175	4	6

Table A-1/M.550 [T9.550], p.

H.T. [T10.550]

TABLE A-2/M.550

Example of maintenance limits for 64 kbit/s digital line sections

Allocation (%)	{ { {								
	ES	SES	DM	ES	SES	DM	ES	SES	DM
0.45	31	1	1	50	10	10	30	1	1
2.0	138	2	3	50	10	10	90	2	3
5.0	346	4	7	50	10	10	200	5	8

Table A-2/M.550 [T10.550], p.

A.3 *Example of bringing-into-service and maintenance limits for digital sections*

The values of Tables A-3/M.550 and A-4/M.550 are measured at the rate of the digital sections and referred to the 64 kbit/s using Annex D of Recommendation G.821 [1].

H.T. [T11.550]

TABLE A-3/M.550

Example of bringing-into-service limits for 64 kbit/s digital paths and sections

Allocation (%)	{ S1 limit Events/3 days ES	S2 limit Events/3 days SES	DM	ES	SES	DM	ES	SES	DM
1	207	3	4	104	1	2	130	2	3
2	415	5	9	207	3	4	250	4	6
3	622	8	13	311	4	6	360	6	9
4	829	10	17	415	5	9	470	7	12
5	1037	13	22	518	6	11	580	9	15
6	1244	16	26	622	8	13	690	11	18

Table A-3/M.550 [T11.550], p.

H.T. [T12.550]

TABLE A-4/M.550

Example of maintenance limits for 64 kbit/s digital sections

Allocation (%)	{ { { ES	SES	DM	ES	SES	DM	ES	SES	DM
1	69	1	1	100	12	12	51	2	2
2	138	2	3	100	12	12	103	3	4
3	207	3	4	100	12	12	155	4	6
4	276	4	6	100	12	12	207	5	8
5	346	4	7	100	12	12	259	6	10
6	415	5	9	100	12	12	311	7	12

Table A-4/M.550 [T12.550], p.

A.4 *Example of bringing-into-service and maintenance limits for digital paths*

The bringing-into-service limits for digital paths are the same as those for digital sections, as shown in Table A-3/M.550.

The values of Table A-5/M.550 are usually measured at the primary rate and referred to the 64 kbit/s rate using Annex D to Recommendation G.821 [1].

H.T. [T13.550]

TABLE A-5/M.550

Example of maintenance limits for 64 kbit/s digital paths

Allocation (%)	{ { {								
	ES	SES	DM	ES	SES	DM	ES	SES	DM
2.5	173	2	4	120	15	15	130	2	3
3.5	242	3	5	120	15	15	181	3	4
4.	276	4	6	120	15	15	207	4	5
5.5	380	5	8	120	15	15	285	5	6
6.	415	5	9	120	15	15	311	6	7

Table A-5/M.550 [T13.550], p.

References

[1] CCITT Recommendation *Error performance of an international digital connection forming part of an integrated services digital network* , Vol. III, Rec. G.821.

[2] CCITT Recommendation *Controlled slip rate objectives on an international digital connection* , Vol. III, Rec. G.822.

[3] CCITT Recommendation *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy* Vol. III, Rec. G.823.

[4] CCITT Recommendation *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy* , Vol. III, Rec. G.824.

[5] CCITT Recommendation *ISDN user-network interfaces — Interface structures and access capabilities* , Vol. III, Rec. I.412.

[6] CCITT Recommendation *Digital hierarchy bit rates* , Vol. III, Rec. G.702.

[7] CCITT Recommendation *Digital transmission models* , Vol. III, Rec. G.801.

[8] CCITT Recommendation *Digital sections based on the 2048 kbit/s hierarchy* , Vol. III, Rec. G.921.

[9] CCITT Recommendation *Digital line sections at 1544 kbit/s* , Red Book, Vol. III, Rec. G.911, ITU, Geneva, 1984.

[10] CCITT Recommendation *Functional characteristics of interfaces associated with network nodes* , Vol. III, Rec. G.704.

Recommendation M.555

BRINGING INTERNATIONAL DIGITAL BLOCKS, PATHS AND SECTIONS INTO SERVICE

1 Preliminary exchange of information

The technical services concerned nominate the control and sub-control stations for the digital block, path or section to be brought into operation in accordance with Recommendations M.80 and M.90.

The technical services should indicate the routing to be followed and the method given in Recommendation M.570 may be applied.

Information necessary for the control station, which will be entered on a *routing form* is indicated below:

— routing of the block, path or section,

— names of control and sub-control stations,

— names of stations where the block or path appears at its characteristic bit rate.

The overall routing form for an entire block or path is drawn up by the control station on the basis of information furnished by its technical service and by each sub-control station for the sections for which the latter is responsible.

Note — When digital paths are used to provide the terrestrial links to a time division multiple access (TDMA) satellite system, the usual digital system supervisory signals (AIS, remote alarm, etc.) are not transmitted over the satellite section. An alternative method of supervision for the individual circuits is described in Recommendation Q.33. [1].

When the block or path is assigned its designation (according to Recommendation M.140 §§ 9 and 10), the Administration with control station responsibility will assemble the necessary technical and operational information. This should be entered into the list of related information (as defined in Recommendation M.140, § 12) which consists of the items shown in the Annex A.

2 Digital system arrangements

2.1 *Digital hierarchy*

The layout of the presently identified hierarchical digital bit rates is given in Table 1/M.555, both for hierarchies based on 1544 kbit/s systems and for hierarchies based on 2048 kbit/s systems.

H.T. [T1.555], p.

TABLE 1/M.555

Hierarchical bit rates

Level	1544 kbit/s structure	2048 kbit/s structure	
1	1544	2 | 48	
2	6312	8 | 48	
3	32 | 64	44 | 36	34 | 68
4	97 | 28	Note	139 | 64

Note — Level 4 bit rates presently under study.

Table 1/M.555 [T1.555], p.

The procedures for introducing services using digital satellite systems are not covered in this Recommendation. This matter is for further study for Study Group IV.

2.2 *Digital interworking arrangements*

(The standard digital interworking arrangements presently under study by Study Group XVIII will be shown when they are available).

3 Reference measurements for a path

The measurements described in § 5.2 below for ensuring that the digital path is within limits also constitute reference measurements. These data should be recorded at every sub-control station and at stations adjacent to frontiers where the block or path appears at its characteristic bit rate. On request, this data should be forwarded to the control station which then can draw up a record of reference measurements.

4 Organization of the control of international digital blocks, digital paths, etc.

4.1 *Classes of station*

4.1.1 As far as international cooperation is concerned, only two classes of through-connection station need to be designated by any country:

a) stations which exercise control functions, i.e., digital block/digital path control stations and digital block/digital path sub-control stations;

b) attended stations nearest the frontier, which in this Recommendation are referred to as *frontier stations* .

4.1.2 In accordance with Recommendations M.80 and M.90, the station at each end of the digital block or digital path is the *control station* for the receiving direction of transmission and the terminal *sub-control station* for the sending direction. Stations having control functions in intermediate countries are digital block, digital path intermediate sub-control stations. Other stations involved in international maintenance are frontier stations.

4.1.3 In general, a transit country will have one station with control functions or one with sub-control functions and two frontier stations. A country in which the digital block or path terminates has only one frontier station. In some countries, a station with control functions or sub-control functions and a frontier station will be the same.

4.2 *Classes of digital sections*

For the purposes of setting-up, making initial tests and subsequent maintenance, an international digital path is subdivided into national sections, international sections and main sections as defined in Recommendation M.300. These terms are illustrated in Figure 1/M.555.

Figure 1/M.555, p.

4.3 *Organization of control functions*

The terminal stations of each national, international and main section will be appointed as a control or sub-control station for that class of section with which they are concerned. However, as a consequence of the definitions of national, international and main sections of a digital path, some stations will be nominated for more than one control or sub-control function. For example, station S in Figure 1/M.555 is:

— control station for main section Q-S,

— sub-control station for main section S-T,

— control station for national section R-S.

5 Setting up and initial testing of an international digital path

5.1 *Setting up the path*

5.1.1 Once the route has been agreed, the (n -th order) digital path control station will direct the operations needed to set up the digital path.

All the repeater stations concerned — i.e., the stations at the ends of each digital section that will make up the digital path — should make setting-up tests and check the equipment to be used. The check should include a general visual inspection and vibration tests , particularly if the equipment has remained unused for some time since acceptance tests were carried out after installation.

5.1.2 Each country sets up the national part within its territory, each international digital section is set up by the stations at the ends of this section in the two countries concerned (generally the frontier stations) and these national and international sections are interconnected as may be appropriate. The sub-control stations inform the control station when each interconnection is completed.

5.2 *Initial testing of the digital path*

5.2.1 The procedure for an international n -th order digital path is based on the progressive testing of its component sections as follows:

i) national and international sections which are then interconnected to form main sections,

ii) main sections which are then interconnected to form the overall path,

iii) overall path.

The setting-up tests should include a quick test of the digital error performance. The function of such a check is not to guarantee compliance with performance objectives nor is it the testing of the system as part of a commissioning process (which might require measurement of margins), but rather to detect any immediate problems instead of having the user do so. Thus, it is analogous to a continuity check of a circuit, not to a measurement of the loss and noise of the circuit. The limits to apply are given in Table 2/M.555.

For these tests, satellite paths should be considered to have an equivalent length of 12 | 00 km.

5.2.2 The following procedures should be used when making the tests recommended in Table 2/M.555:

1) All tests should be performed at a first order digital connection point. Thus, tests of second order and other higher bit rate digital systems must have the appropriate multiplexers and demultiplexers in the test path. This ensures a complete test of the path regardless of its bit rate.

2) A test of digital path between two stations is set up by connecting a QRSS (quasi-random signal source) to the input for the digital path at the transmitting station distribution frame and connecting the output at the receiving station distribution frame to a receive input of a test set such as that described in Recommendation O.151 [2].

3) Tests may be one way in each direction or ‘‘looped’’ (combined 2-way). If looped, then test equipment is required at only one location, and the other end is arranged to be looped back (output connected to the input at the distribution frame).

4) Test equipment should have the features described in Recommendation O.151 [2]. Back-to-back tests of test equipment should occasionally be performed (connect output to input on the same test instrument) to test for locally generated errors due to unfiltered a.c. power or station equipment interference. In general, whenever possible, use protected d.c. power for all test equipment.

5) The results of error tests may be contaminated by events which cause the test instrument to lose synchronization. In general, all such ‘‘lost sync’’ tests should be repeated.

6) If the tests fail:

a) Determine if some special circumstance was responsible for a circuit interruption or high error rate. If it was, repeat the test to verify that the circuit is working correctly.

b) If no special circumstance is found, an attempt should be made to isolate the problem section for repair or replacement. If the digital path starts to function correctly during trouble isolation, repeat the original test.

c) For marginal failures (i.e. just a few counts over the limit), the test should be repeated, but with the time limit and the maximum allowable count doubled.

H.T. [T2.555], p.

TABLE 2/M.555

Quick check test of digital error performance for digital section and paths at the primary rate (Provisional)

Effective distance (kilometres)	Minimum test duration (in minutes)	Maximum allowed counts a) in errored seconds b)
| 00	15	5
1 | 00	15	10
2 | 00	15	20
4 | 00	15	40
8 | 00	15	80
12 | 00	15	125
18 | 00	15	180
25 | 00	15	250

a) Values relate to 1.5 or 2.0 Mbit/s and may be linearly interpolated for other distances.

b) For the meaning of the term ‘‘errored seconds’’, see Recommendation G.821 | 3].

Table 2/M.555 [T2.555], p.

6 Setting up lower-order sections after the initial testing of the higher-order paths

The different hierarchical orders of sections have to be set up in sequence.

6.1 Thus, when the digital path has been initially tested, each end of it is connected to the appropriate digital multiplexing equipment and the corresponding lower-order sections are then set up.

6.2 In each case, the digital multiplexing equipment, before it is connected to the ends of its associated path, must be checked and adjusted to ensure that it meets CCITT Recommendations and other relevant specifications.

6.3 When the lower-order sections have been set up in the above manner, they are interconnected as necessary to form paths, as described in § 5.1 above, and the appropriate path testing procedure as detailed in § 5.2 above, is then applied.

ANNEX A

(to Recommendation M.555)

Designation information of international digital blocks and paths

A.1 *Designation*

The designation is according to Recommendation M.140, §§ 9 and 10.

A.2 *Related information*

The additional information on digital blocks, etc. is covered by the following items:

RI 1. urgency for restoration;

RI 2. terminal countries;

RI 3. carriers' names;

RI 4. control and subcontrol station(s);

RI 5. fault report points;

RI 6. routing;

RI 7. association;

RI 8. equipment information;

RI 9. use;

RI 10. transmission medium;

RI 11. (empty item, use ''—''); only for the mixed analogue/digital network: end-to-end information;

RI 12. bit rate;

RI 13. occupancy (for blocks);

RI 14. actual number of channels (for primary blocks);

RI 15. clocking information (for blocks);

RI 16. direction of transmission (for unidirectional blocks).

The various items will be dealt with in § 12 of Recommendation M.140.

References

[1] CCITT Recommendation *Protection against the effects of faulty transmission on groups and circuits* , Vol. VI, Rec. Q.33.

[2] CCITT Recommendation *Error performance measuring equipment for digital systems* , Vol. IV, Rec. O.151.

[3] CCITT Recommendation *Error performance of an international digital connection forming part of an integrated services digital network* , Vol. III, Rec. G.821.

Recommendation M.556

SETTING UP AND INITIAL TESTING OF DIGITAL CHANNELS

ON AN INTERNATIONAL DIGITAL PATH OR BLOCK

The definition of a digital channel is given in Recommendation M.300. Procedures in CCITT Recommendation M.555 for bringing-into-service digital blocks and digital paths are adequate to ensure satisfactory operation of digital channels which are provided on the respective digital blocks or paths. No specific tests are required for individual digital channels.

Where digital channels are terminated at each end by mixed analogue/digital terminals, Administrations may, with bilateral agreement, choose to apply a procedure similar to that in CCITT Recommendation M.470, to test from each audio input to each audio output. This procedure is an alternative to the mixed analogue/digital terminal circuit section line-up procedure in CCITT Recommendation M.580.

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