TTC Specification
Technical Specification

TS-1000

Optical Subscriber Line Interface - 100 Mbit/s Single-fiber Bi-directional Interface by WDM - (English Edition)

Version 2

Issued on January 27, 2004

THE TELECOMMUNICATION TECHNOLOGY COMMITTEE

Figure.I-1/TS-1000 of this document reprinted with permission from IEEE std 802.3-2000 “Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications” Copyright 2000, by IEEE. The IEEE disclaims any responsibility or liability resulting from the placement and use in the described manner.

This document provides the TTC original Technical Specification formulated by the TTC Technical Committee .

In case of dispute, the original to be referred is the Japanese Edition, Version2 issued on January 27, 2004 of the text.

This English Edition issued on January 27, 2004.

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<Reference Information>

1. Relationship with the International Recommendations

This Technical Specification describes an optical interface that has operations, administration and maintenance (OAM) functions for transmitting 100BASE-FX codes with the single-fiber optical system. There are no relevant standards such as international recommendations.

2. Additions to the International Recommendations

This Technical Specification describes that the wavelength range of the 1550 nm region shall be 1480 nm to 1580 nm as defined in the TTC Standards and ITU-T Recommendations. However, when the wavelength range is to be shifted toward a longer wavelength region for current economical reasons, the wavelength range may be 1500 nm to 1600 nm. Moreover, to support this wavelength range, the optical detection range of a terminal media converter (MC) should be 1480 nm to 1600 nm.

3. Revision History

Edition and Version	Date of issue	Description
English Edition, Version 1	November 11 , 2002	Issued
English Edition, Version 2	January 27,2004	Revised

4. Others

(1) With this Technical Specification, the items below are subject to further study.

(a) Definition of OAM frame bits other than those defined in Table 5-3/TS-1000 (Section 5.3)

(b) Vendor code used by a vendor that has not acquired any OUIs defined in IEEE Standard 802-1990 (Section 5.3)

(2) Referenced Recommendations and Standards

TTC Standard: JT-G957, JT-G983.1

ITU-T Recommendation: G.652

IEEE Standard: 802-1990, 802.3-2000

5. Standard Preparation Department

Working Group on UNI and NNI transmission

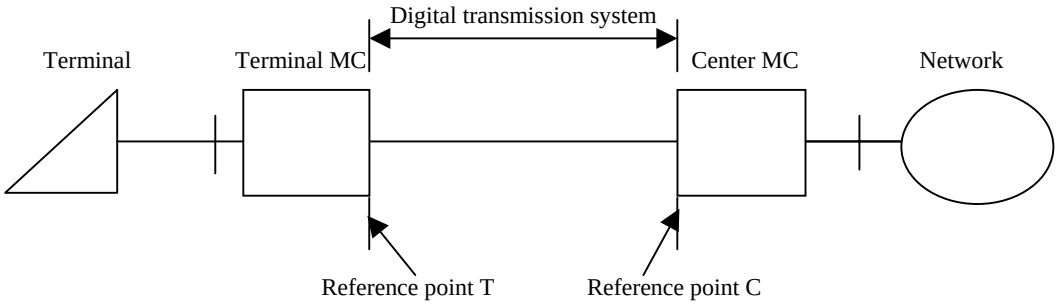
1. Scope of the Specification

This Technical Specification describes the optical interface and logical functions of a media converter applied for a single single-mode fiber, that has operations, administration and maintenance functions such as a loop back test function, from the viewpoint of optical fiber utilization and communication equipment maintainability.

This Technical Specification describes the characteristics at the reference points T and C of the digital transmission system between the center media converter and terminal media converter shown in Figure 1-1/TS-1000. The optical fiber defined in ITU-T Recommendation G.652 is used for the digital transmission system indicated in that Figure.

In this Technical Specification, a media converter may be referred to as an MC unless otherwise noted.

In this Technical Specification, the MC is a device that has a function for conversion between the optical interface described in this Technical Specification and an interface capable of transmitting and receiving MAC frames defined in IEEE Standard 802.3. In an access system, the center MC corresponds to an OLT in a network architecture (Figure 5-1/JT-G983.1) defined in TTC Standard JT-G983.1, and the terminal MC corresponds to an ONU or ONT (in the case of FTTH) in the same network architecture.



MC: Media converter

Reference point: Point on the optical fiber adjacent to an optical connection point (optical connector or optical splice)

Figure 1-1/TS-1000 Optical interface reference configuration of media converters

2. Reference

(1) TTC Standard JT-G957 "Optical Interface for Equipment and Systems Relating to the Synchronous Digital Hierarchy"

(2) TTC Standard JT-G983.1 " Broadband Optical Access System Based on Passive Optical Network (PON)"

(3) ITU-T Recommendation G.652-1997 "Characteristics of a single-mode optical fibre cable"

(4) IEEE Standard 802.3-2000 "Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications"

3. Abbreviations

- CRC-8: 8-bit cyclic redundancy check
- ESD: End of stream delimiter
- FCS: Frame check sequence
- FEFI: Far end fault indication
- ffs: for further study
- FTTH: Fiber to the home
- IDL: Idle
- IFG: Inter-frame gap

- LAN CSMA/CD: Local area network carrier sense multiple access with collision detection
- MAC: Media access control
- MC: Media converter
- MDI: Medium dependent interface
- MII: Media independent interface
- MLM: Multi-longitudinal mode
- OAM: Operations, administration and maintenance
- OLT: Optical line termination
- ONT: Optical network termination (in the case of FTTH)
- ONU: Optical network unit
- OUI: Organizationally unique identifier
- PA: Preamble
- PCS: Physical coding sublayer
- PMA: Physical medium attachment
- PMD: Physical medium dependent
- RMS: Root mean square
- RS: Reconciliation sublayer
- RX_DV: Receive data valid
- RXD<3:0>: Receive data bit 3 through 0
- SFD: Start frame delimiter
- SLM: Single longitudinal mode
- SSD: Start of stream delimiter
- TXD<3:0>: Transmit data bit 3 through 0
- TX_EN: Transmit enable
- /I/: Idle code-group

4. Glossary

- OAM signal

  Signal for OAM transmitted by a center MC to a terminal MC or by a terminal MC to a center MC
- OAM frame

  Frame with a fixed length of 96 bits used for transmission of an OAM signal by a center MC to a terminal MC or by a terminal MC to a center MC
- OAM information

  Information carried by an OAM signal transmitted with an OAM frame by a center MC to a terminal MC or by a terminal MC to a center MC
- MII nibble

  A set of 4-bit binary data used by the MII
- Loop back test frame

  Test frame that is transmitted by a center MC to a terminal MC and is transmitted back by the terminal MC to the center MC during a loop back test, in order to check if the transmission between the center MC and terminal MC is normal
- Loop back test start request frame

  OAM frame transmitted by a center MC to a terminal MC in order to request the start of loop back test settings

- Loop back test start response frame

  OAM frame that is transmitted by a terminal MC to a center MC, in response to a loop back test start request frame transmitted by the center MC to the terminal MC, in order to notify the completion of loop back test settings by the terminal MC to the center MC
- Loop back test end request frame

  OAM frame that is transmitted by a center MC to a terminal MC in order to request the cancellation of loop back test settings
- Loop back test end response frame

  OAM frame that is transmitted by a terminal MC to a center MC, in response to a loop back test end request frame transmitted by the center MC to the terminal MC, in order to notify the completion of loop back test settings cancellation by the terminal MC to the center MC
- Status notification request frame

  OAM frame that is transmitted by a center MC to a terminal MC in order to request the notification of the statuses being monitored by the terminal MC
- Status notification response frame

  OAM frame that is transmitted by a terminal MC to a center MC, in response to a status notification request frame transmitted by the center MC to the terminal MC, in order to notify the statuses being monitored by the terminal MC to the center MC
- Status notification indication frame

  OAM frame that is transmitted by a terminal MC to a center MC or by a center MC supporting Option A to a terminal MC, for autonomous notification of any changes in the statuses being monitored by the terminal MC or the center MC supporting Option A, respectively
- User frame

  Frame that is transmitted by a center MC to a terminal MC or by a terminal MC to a center MC, in order to carry a MAC frame defined in IEEE Standard 802.3

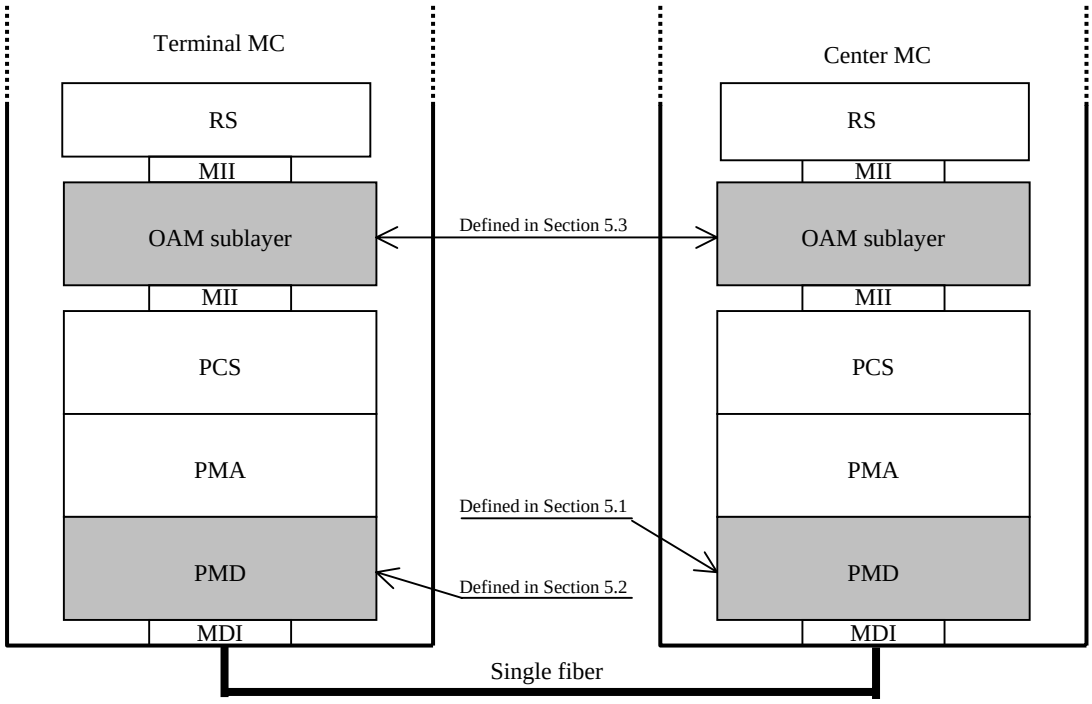
5. Optical Transmission Interface Specification

The optical transmission interface shall conform to IEEE Standard 802.3 100BASE-FX (PMA, PCS, MII, and RS layers), except that PMD layer specifications are provided in Section 5.1 and Section 5.2 below. The PMD layer specification is provided for each of the following application classes:

(1) Class S: Optical line loss of 15 dB, optical path penalty of 1 dB
(2) Class Ar: Optical line loss of 20dB, optical path penalty of 1dB (r: for reduced range)
(3) Class B: Optical line loss of 25dB, optical path penalty of 1dB

As another exception, an OAM sublayer specification is provided in Section 5.3.

The scope of this Technical Specification in the LAN CSMA/CD layer configuration is as shown in Figure 5-1/TS-1000.



RS: Reconciliation sublayer
MII: Media independent interface
PCS: Physical coding sublayer
PMA: Physical medium attachment
PMD: Physical medium dependent
MDI: Medium dependent interface

Figure 5-1/TS-1000 Relationships between LAN CSMA/CD layer configuration and this Technical Specification

5.1 Physical Layer Specification of the Center MC

5.1.1 Central wavelength

At the reference point C, the central wavelength of a launched signal shall be within the range of 1480 nm to 1580 nm,

and the central wavelength of a received signal shall be within the range of 1260 nm to 1360 nm.

5.1.2 Spectral characteristic of a launched signal

For an MLM laser, a spectral characteristics is specified with a maximum root-mean-square (RMS) width of the spectral distribution under standard operating conditions. An RMS width means the standard deviation (σ) of the spectral distribution. In the maximum RMS width measurement, all laser modes that are not more than 20 dB down from the peak mode should be considered.

For an SLM laser, a spectral characteristics is specified with a maximum –20 dB width and minimum side mode suppression ratio. The maximum –20 dB width is defined as the maximum full width of the central wavelength peak, measured 20 dB down from the maximum amplitude of the central wavelength under standard operating conditions. Moreover, the minimum side mode suppression ratio is defined to suppress the mode distribution noise of an SLM system.

The spectral characteristics of a launched signal is provided in Table 5-1/TS-1000.

Table 5-1/TS-1000 Spectral characteristics of a launched signal

	Unit	Class S	Class Ar	Class B
Source type	-	MLM	MLM	SLM
Maximum RMS width	nm	4.6	3.0(*)	-
Maximum -20 dB width	nm	-	-	1
Minimum side mode suppression ratio	dB	-	-	30

* When more economical fabrication technologies for MLM's with smaller RMS width will be available in future, the selection of smaller value for "Maximum RMS width" should be recommended (See Appendix III).

5.1.3 Mean launched power

The mean launched power is an average optical level for a pseudo random pattern. The maximum and minimum values of mean launched power at the reference point C are provided in Table 5-2/TS-1000.

Table 5-2/TS-1000 Mean launched power

	Unit	Class S	Class Ar	Class B
Maximum value of mean launched power	dBm	-8	-3	0
Minimum value of mean launched power	dBm	-14	-9	-5

5.1.4 Sensitivity and overload for the received optical signal

Sensitivity and overload are defined for an average optical level for a pseudo random pattern. The minimum sensitivity and overload at the reference point C are provided in Table 5-3/TS-1000.

Table 5-3/TS-1000 Sensitivity and overload

	Unit	Class S	Class Ar	Class B
Minimum overload	dBm	-8	-3	-3
Minimum sensitivity(*)	dBm	-30	-30	-31

* This value includes a power penalty due to dispersion and so forth.

5.1.5 Extinction ratio

The logical values associated with optical emission shall be such that logical value 1 represents light emission and logical value 0 represents no light emission.

An extinction ratio (EX) is defined by the following expression:

$EX = 10\ log_{10}(A/B)$

Here, A represents an average light emission level for logical value 1, and B represents an average light emission level for logical value 0.

Table 5-4/TS-1000 Extinction ratio

	Unit	Class S	Class Ar	Class B
Extinction ratio	dB	8.2 or more	10 or more	10 or more

5.1.6 Pulse mask

The pulse mask for a launched signal at the reference point C shall conform to Figure 2/JT-G957 STM-0/STM-1 of TTC Standard JT-G957.

For the pulse mask measurement, a 4th-order or 5th-order Bessel-Thomson filter with a cut-off frequency of 125 MHz × 0.75 shall be used. However, a 4th-order or 5th-order Bessel-Thomson filter with a cut-off frequency of 155.52 MHz × 0.75 may be used.

5.1.7 S/X tolerance

The spatial discontinuity of refractive index on the optical path causes multiple reflection, so that the center MC receives both of the resultant reflection-caused optical noises (X) and the optical signal (S) transmitted by the terminal MC. The center MC shall have an appropriate S/X tolerance against the reflection from the optical path that satisfies the return loss specified below.

It is assumed that a reflection model used here consists of a center MC, a terminal MC, an optical path connecting them, and two near-end connectors on the optical path, as shown in Figure 5-2/TS-1000. Here, the minimum return loss of one connector is assumed to be 35 dB, and the minimum return loss of two connectors is assumed to be 32 dB.

When the total return loss of an optical signal transmitted by the center MC, that is due to the reflection from the optical path and at the terminal MC, is as shown in Table 5-5/TS-1000, the bit error rate provided in Table 5-5/TS-1000 shall be satisfied for the received optical signal within the optical level range defined in Section 5.1.4.

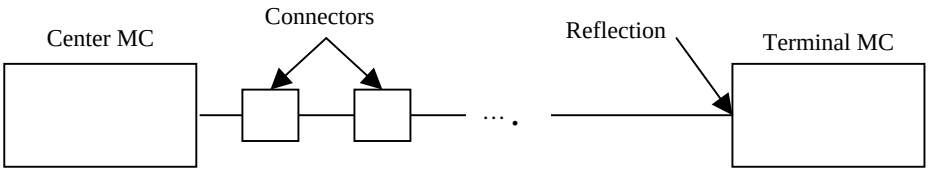


Figure 5-2/TS-1000 Reflection model

Table 5-5/TS-1000 S/X tolerance

		Class S	Class Ar	Class B
S/X tolerance	Return loss(*)	14 dB or more	14 dB or more	14 dB or more
	Bit error rate	1×10^{-10} or less	1×10^{-10} or less	1×10^{-10} or less

* The minimum return loss of the terminal MC is 14 dB (Section 5.2.8), but the minimum return loss of the two connectors is 32 dB. The resultant reflection-caused noise due to the latter is negligible small in comparison with the noise due to the former. So, the minimum value of the total return loss of the optical path viewed from the center MC can be assumed to be 14 dB.

5.1.8 Reflection

When the center MC is viewed from the optical path, the reflection toward the optical path of the optical signal with a central wavelength of 1260 nm to 1360 nm transmitted to the center MC shall satisfy the values provided in Table 5-6/TS-1000.

Table 5-6/TS-1000 Return loss

	Class S	Class Ar	Class B
Return loss	14 dB or more	14 dB or more	14 dB or more

5.1.9 Test pattern

For test patterns used for the measurement of central wavelength, spectral width, and so forth, nothing is specified. However, the short continuous random test pattern described in Annex 36A.5 of IEEE Standard 802.3 may be referred to.

5.1.10 Jitter specification

Jitter means small variations in a short time range of an optical signal, caused by the electrical-to-optical conversion in a optical transmitter, or by the influences of the optical path and so forth.

In this Technical Specification, the duty distortion of a transmitted signal is specified with a pulse mask. In this Section, it is recommended that the jitter on the transmission side excluding a duty distortion be 1 ns or less, and the jitter tolerance on the reception side excluding a duty distortion be 2.5 ns or more.

On the reception side, a duty distortion specified with a pulse mask on the transmission side shall be considered in addition to the jitter tolerance mentioned above.

5.1.11 Signal detect specification

A disconnection of communications due to an optical connector left open, power supply failure in the terminal MC, and so forth shall be detected, and no incorrect link shall be established.

5.1.12 Optical connector

The shape and characteristics of an optical connector are not specified.

5.2 Physical Layer Specification of the Terminal MC

5.2.1 Central wavelength

At the reference point T, the central wavelength of a launched signal shall be within the range of 1260 nm to 1360 nm, and the central wavelength of a received signal shall be within the range of 1480 nm to 1580 nm.

5.2.2 Spectral characteristics of a launched signal

For an MLM laser, a spectral characteristics is specified with a maximum root-mean-square (RMS) width of the spectral distribution under standard operating conditions. An RMS width means the standard deviation (σ) of the spectral distribution. In the maximum RMS width measurement, all laser modes that are not more than 20 dB down from the peak mode should be considered.

For an SLM laser, a spectral characteristics is specified with a maximum –20 dB width and minimum side mode suppression ratio. The maximum –20 dB width is defined as the maximum full width of the central wavelength peak, measured 20 dB down from the maximum amplitude of the central wavelength under standard operating conditions. Moreover, the minimum side mode suppression ratio is defined to suppress the mode distribution noise of an SLM system.

The spectral characteristics of a launched signal is provided in Table 5-7/TS-1000.

Table 5-7/TS-1000 Spectral characteristics of a launched signal

	Unit	Class S	Class Ar	Class B	
Source type	-	MLM	MLM	MLM	SLM
Maximum RMS width	nm	7.7	7.0	4.7	-
Maximum -20 dB width	nm	-	-	-	1
Minimum side mode suppression ratio	dB	-	-	-	30

5.2.3 Mean launched power

The mean launched power is an average optical level for a pseudo random pattern. The maximum and minimum values of mean launched power at the reference point T are provided in Table 5-8/TS-1000.

Table 5-8/TS-1000 Mean launched power

	Unit	Class S	Class Ar	Class B
Maximum value of mean launched power	dBm	-8	-3	0
Minimum value of mean launched power	dBm	-14	-9	-5

5.2.4 Sensitivity and overload of received optical signal

The sensitivity and overload are defined for an average optical level for a pseudo random pattern. The minimum sensitivity and overload at the reference point T are provided in Table 5-9/TS-1000 .

Table 5-9/TS-1000 Sensitivity and overload

	Unit	Class S	Class Ar	Class B
Minimum overload	dBm	-8	-3	-3
Minimum sensitivity(*)	dBm	-30	-30	-31

* This value includes a power penalty due to dispersion and so forth.

5.2.5 Extinction ratio

The logical values associated with optical emission shall be such that logical value 1 represents light emission and logical value 0 represents no light emission.

An extinction ratio (*EX*) is defined by the following expression:

$EX = 10\ log_{10}(A/B)$

Here, *A* represents an average light emission level for logical value 1, and *B* represents an average light emission level for logical value 0.

Table 5-10/TS-1000 Extinction ratio

	Unit	Class S	Class Ar	Class B
Extinction ratio	dB	8.2 or more	10 or more	10 or more

5.2.6 Pulse mask

The pulse mask for a launched signal at the reference point T shall conform to Figure 2/JT-G957 STM-0/STM-1 of TTC Standard JT-G957.

For the pulse mask measurement, a 4th-order or 5th-order Bessel-Thomson filter with a cut-off frequency of 125 MHz × 0.75 shall be used. However, a 4th-order or 5th-order Bessel-Thomson filter with a cut-off frequency of 155.52 MHz × 0.75 may be used.

5.2.7 S/X tolerance

The spatial discontinuity of refractive index on the optical path causes multiple reflection, so that the terminal MC receives both of the resultant reflection-caused optical noises (X) and the optical signal (S) transmitted by the center MC. The center MC shall have an appropriate S/X tolerance against the reflection from the optical path that satisfies the return loss specified below.

It is assumed that a reflection model used here consists of a center MC, a terminal MC, an optical path connecting them, and two near-end connectors on the optical path, as shown in Figure 5-3/TS-1000. Here, the minimum return loss of one connector is assumed to be 35 dB, and the minimum return loss of two connectors is assumed to be 32 dB.

When the total return loss of an optical signal transmitted by the terminal MC, that is due to the reflection from the optical path and at the center MC, is as shown in Table 5-11/TS-1000, the bit error rate provided in Table 5-11/TS-1000 shall be satisfied for the received optical signal within the optical level range defined in Section 5.2.4.

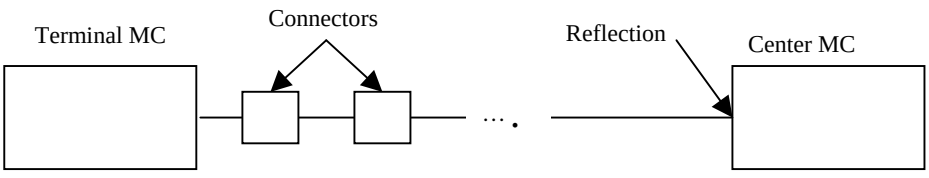


Figure 5-3/TS-1000 Reflection model

Table 5-11/TS-1000 S/X tolerance

		Class S	Class Ar	Class B
S/X tolerance	Return loss(*)	14 dB or more	14 dB or more	14 dB or more
	Bit error rate	1×10^{-10} or less	1×10^{-10} or less	1×10^{-10} or less

* The minimum return loss of the center MC is 14 dB (Section 5.1.8), but the minimum return loss of the two connectors is 32 dB. The resultant reflection-caused noise due to the latter is negligible small in comparison with the noise due to the former. So, the minimum value of the total return loss of the optical path viewed from the terminal MC can be assumed to be 14 dB.

5.2.8 Reflection

When the terminal MC is viewed from the optical path, the reflection toward the optical path of the optical signal with a central wavelength of 1480 nm to 1580 nm transmitted to the terminal MC shall satisfy the values provided in Table 5-12/TS-1000.

Table 5-12/ TS-1000 Return loss

	Class S	Class Ar	Class B
Return loss	14 dB or more	14 dB or more	14 dB or more

5.2.9 Test pattern

For test patters used for the measurement of central wavelength, spectral width, and so forth, nothing is specified. However, the short continuous random test pattern described in Annex 36A.5 of IEEE Standard 802.3 may be referred to.

5.2.10 Jitter specification

Jitter means small variations in a short time range of an optical signal, caused by the electrical-to-optical conversion in a optical transmitter, or by the influences of the optical path and so forth.

In this Technical Specification, the duty distortion of a transmitted signal is specified with a pulse mask. In this Section, it is recommended that the jitter on the transmission side excluding a duty distortion be 1 ns or less, and the jitter tolerance on the reception side excluding a duty distortion be 2.5 ns or more.

On the reception side, a duty distortion specified with a pulse mask on the transmission side shall be considered in addition to the jitter tolerance mentioned above.

5.2.11 Signal detect specification

A disconnection of communications due to an optical connector left open, power supply failure in the center MC, and so forth shall be detected, and no incorrect link shall be established.

5.2.12 Optical connector

The shape and characteristics of an optical connector are not specified.

5.3 OAM Signal

This Section describes OAM signals transmitted by the terminal MC to the center MC or by the center MC to the terminal MC.

The OAM signals are transmitted using a frame with a fixed length of 96 bits, coded in conformance to IEEE Standard 802.3 100BASE-FX, and are used for the purposes listed below.

(1) Status notification request by the center MC to the terminal MC
Status notification request (Center MC → Terminal MC)
Status notification response (Terminal MC → Center MC)

(2) Status notification indication by the terminal MC to the center MC (when the terminal MC supports Option B, that enables the notification of set statuses for the terminal-side link of the terminal MC)
Status notification indication (Terminal MC → Center MC)

(3) Status notification indication by the center MC to the terminal MC (when the center MC supports Option A, that enables the notification of some statuses of the center MC)
Status notification indication (Center MC → Terminal MC)

(4) Loop back test start and end request by the center MC to the terminal MC,
and loop back test end indication by the terminal MC to the center MC
Loop back test start request (Center MC → Terminal MC)
Loop back test start response (Terminal MC → Center MC)
Loop back test end request (Center MC → Terminal MC)
Loop back test end response (Terminal MC → Center MC)
Loop back test end indication (Terminal MC → Center MC)

5.3.1 OAM signal specification

The OAM frame format on the media independent interface (MII) is shown in Figure 5-4/TS-1000.

Moreover, the bit definitions of the OAM frame, and the values to be assigned to the bits of each OAM frame type are provided in Table 5-13/TS-1000 and Table 5-14/TS-1000, respectively.

	TXD0/RXD0	F0	F4	C0	C4	C8	C12	S0	S4	S8	S12	M0	M4	M8	M12	M16	M20	M24	M28	M32	M36	M40	M44	E0	E4
MII	TXD1/RXD1	F1	F5	C1	C5	C9	C13	S1	S5	S9	S13	M1	M5	M9	M13	M17	M21	M25	M29	M33	M37	M41	M45	E1	E5
Nibble	TXD2/RXD2	F2	F6	C2	C6	C10	C14	S2	S6	S10	S14	M2	M6	M10	M14	M18	M22	M26	M30	M34	M38	M42	M46	E2	E6
	TXD3/RXD3	F3	F7	C3	C7	C11	C15	S3	S7	S11	S15	M3	M7	M11	M15	M19	M23	M27	M31	M35	M39	M43	M47	E3	E7

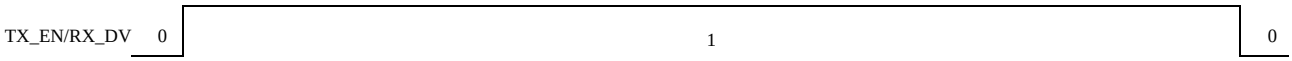


Figure 5-4/TS-1000 OAM frame format on the MII

Table 5-13/TS-1000 Bit definitions of the OAM frame

Bit position	Item		Description	Remarks
F0-F7	Preamble		1010 1010	Fixed
C0	OAM signal identifier		0	Fixed
C1	Direction identifier		0: Upstream (Terminal MC → Center MC) 1: Downstream (Center MC → Terminal MC)	
C2-C3	Instruction identifier		10: Request 11: Response 01: Indication 00: Reserved	
C4-C7	Version		0000	Fixed
C8-C15	Control signal		10 00 00 00: Start loop back test 00 00 00 00: End loop back test 01 00 00 00: Notify statuses Others: Reserved	
S0	Statuses	Power supply status	0: Normal 1: Power supply failure	
S1		Status of the received optical signal	0: Normal 1: Abnormal	
S2		Terminal-side/network-side link status	0: Established 1: Unestablished or disconnected Nothing is specified when S11 is set to 1 in binary.	
S3		MC status	0: Normal 1: Failure	
S4		Loss-of-optical-signal notification method	0: With OAM frame 1: With alarm FEFI	
S5		Operation status	0: Under ordinary operation 1: Under loop back test	
S6		Support for notification of set statuses for the terminal-side link (Option B)	0: Not supported 1: Supported Nothing is specified when S11 is set to 1 in binary.	
S7-S8		Set rate of the terminal-side link	00 in binary when S6 is set to 0 in binary. The following values are applicable when S6 is set to 1 in binary: 00: 10 Mbit/s 01: 100 Mbit/s 10: 1 Gbit/s 11: Other rate Nothing is specified when S2 is set to 1 in binary. Nothing is specified when S11 is set to 1 in binary.	
S9		Set duplex communication status of the terminal-side link	0 in binary when S6 is set to 0 in binary. The following values are applicable when S6 is set to 1 in binary: 1: Full duplex 0: Half duplex Nothing is specified when S7-S8 are set to 11 in binary. Nothing is specified when S2 is set to 1 in binary. Nothing is specified when S11 is set to 1 in binary.	
S10		Set status of automatic negotiation function of the terminal-side link	0 in binary when S6 is set to 0 in binary. The following values are applicable when S6 is set to 1 in binary: 1: Enabled 0: Disabled Nothing is specified when S7-S8 are set to 11 in binary. Nothing is specified when S11 is set to 1 in binary.	
S11		Number of physical interfaces making up the terminal-side/network-side link	0: One 1: Greater than one	
S12-S15		Reserved	0000	
M0-M23	Vendor code		The 1st through 24th bits of an OUI of the vendor who is the supplier of the MC. The vendor code used by a vendor that has not acquired any OUIs is subject to further study.	

Bit position	Item	Description	Remarks
M24-M47	Model number	Vendor can assign value without informing TTC of it.	
E0-E7	FCS	CRC-8	

Note 1) For an OAM frame that has 0000 set in binary in the version area (C4-C7), control signals other than those provided in Table 5-13/TS-1000 are subject to further study. When an OAM frame that has signals other than those provided in Table 5-14/TS-1000 in the C area is received, the OAM information in the S and M areas shall be ignored.

Note 2) All of the reserved bits (S12-S15) in the S area shall be set to 0 in binary at the time of transmission, and shall be ignored at the time of reception. For the values at the time of transmission, however, "the values to be assigned to the bits of each OAM frame type" provided in Table 5-14/TS-1000 have priority over the values provided in this Table.

Note 3) For a terminal MC that supports Option B, S6 shall be set to 1 in binary, and S7-S10 shall be set to the values provided in Table 5-13/TS-1000. For a terminal MC that does not support Option B, all of S6-S10 shall be set to 0 in binary.

Note 4) When a center MC that supports Option B receives an OAM frame with S6 set to 1 in binary, the center MC shall process the OAM information in S7-S10 as the values provided in Table 5-13/TS-1000. When a center MC that supports Option B receives an OAM frame with S6 set to 0 in binary, the center MC shall ignore the OAM information in S7-S10. A center MC that does not support Option B shall ignore the OAM information in S6-S10.

Note 5) For the vendor code bits (M0-M23) in the M area, the 1st, 2nd, 3rd, …, and 24th bit of the binary representation of the OUI defined in IEEE Standard 802-1990, shall be assigned to the bit M0, M1, M2, …, and M23, respectively. For an OUI used for the vendor code, each vendor shall select a single OUI from one or more OUIs that it has acquired, and shall inform TTC of the OUI selected for its vendor code. However, the vendor code used by a vendor that has not acquired any OUIs is subject to further study.

Note 6) The calculation range for the FCS bits (E0-E7) in the E area shall be the information area of C0-M47.

Note 7) For a terminal MC, "terminal-side/network-side link status" (S2) in the S area shall be specified only when its terminal-side link physically consists of a single interface (i.e. when S11=0). For a center MC supporting Option A, "terminal-side/network-side link status" (S2) in the S area shall be specified only when its network-side link physically consists of a single interface (i.e. when S11=0). When the terminal-side link of the terminal MC/network-side link of the center MC supporting Option A physically consists of multiple interfaces (i.e. when S11=1), for "terminal-side/network-side link status" (S2) nothing is specified except for the case of Note 9 below. For "terminal-side/network-side link status" (S2) for a center MC not supporting Option A, nothing is not specified.

Note 8) If a center MC receives an OAM frame with "the number of physical interfaces making up the terminal-side/network-side link" (S11) set to 1 in binary, the center MC shall ignore the OAM information in S2. Moreover, if a center MC supporting Option B receives an OAM frame with "the number of physical interfaces making up the terminal-side/network-side link" (S11) set to 1 in binary, the center MC shall ignore the OAM information in S6-S10.

Note 9) For "the number of physical interfaces making up the terminal-side/network-side link" (S11) in the S area, "one" may be specified (i.e. S11 may be set to 0 in binary), even if the terminal-side link of the terminal MC/network-side link of the center MC physically consists of multiple interfaces, provided that values can be assigned to some bits in the S area at the time of transmission in the same way as in the case of physically consisting of a single interface (as mentioned below). In this case, the terminal MC shall have S2 and S6-S10 set to values specified in this Table, and the center MC supporting Option A shall have S2 set to a value specified in this Table. Processing at the reception by the MC on the remote side of the transmitting MC shall be performed as in the case of physically consisting of a single interface.

(1) When each of the physical interfaces making up the terminal-side link of the terminal MC/network-side link of the center MC has a one-to-one correspondence with one optical interface defined in this Technical Specification,

and the statuses for each physical interface are used for the corresponding optical interface. In this case, this one-to-one correspondence may be fixed (i.e. "one-to-one correspondence" cannot be configured with any operation) or may be configurable (i.e. various types of "one-to-one correspondence" can be configured with some operation).

(2) When the statuses for a particular one of the multiple physical interfaces making up the terminal-side link of the terminal MC/network-side link of the center MC are used as statuses for that link. In this case, one particular physical interface may be fixed (i.e. "one particular interface" cannot be changed with any operation) or may be selectable (i.e. "one particular interface" can be selected with some operation).

Table 5-14/TS-1000 Values to be assigned to the bits of each OAM frame type

<table>
<tr><th rowspan="2">Bit position</th><th rowspan="2">Item</th><th rowspan="2">Description</th><th colspan="2">Start loop back test</th><th colspan="3">End loop back test</th><th colspan="4">Notify statuses</th></tr>
<tr><th>Request</th><th>Response</th><th>Request</th><th>Response</th><th>Indication</th><th>Request</th><th>Response</th><th>Indication (Upstream)</th><th>Indication (Down-stream)</th></tr>
<tr><td>C0</td><td>OAM signal identifier</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>C1</td><td>Direction identifier</td><td>0: Upstream (Terminal MC → Center MC)
1: Downstream (Center MC → Terminal MC)</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>C2-C3</td><td>Instruc-tion identifier</td><td>10: Request 11: Response
01: Indication 11: Reserved</td><td>10</td><td>11</td><td>10</td><td>11</td><td>01</td><td>10</td><td>11</td><td>01</td><td>01</td></tr>
<tr><td>C4-C7</td><td>Version</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td><td>0000</td></tr>
<tr><td>C8</td><td rowspan="3">Control signal</td><td rowspan="3">1000 0000:
Start loop back test
0000 0000:
End loop back test
0100 0000:
Notify statuses
Others:
Reserved</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>C9</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>C10-C15</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td></tr>
<tr><td>S0-S4</td><td rowspan="4">Statuses</td><td rowspan="4"></td><td rowspan="4">Nothing is specified</td><td>Reflect statuses (*2)</td><td rowspan="4">Nothing is specified</td><td>Reflect statuses (*2)</td><td>Reflect statuses (*2)</td><td rowspan="4">Nothing is specified</td><td rowspan="3">Reflect statuses (*1) (*2)</td><td rowspan="3">Reflect statuses (*1) (*2)</td><td rowspan="4">Reflect statuses in S1, S2, S3, and S11. For others nothing is specified. (*2)</td></tr>
<tr><td>S5</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>S6-S11</td><td>Reflect statuses (*1) (*2)</td><td>Reflect statuses (*1) (*2)</td><td>Reflect statuses (*1) (*2)</td></tr>
<tr><td>S12-S15</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td><td>All set to 0 in binary</td></tr>
</table>

M0-M23	Vendor code	The 1st through 24th bits of an OUI of the vendor who is the supplier of the MC. The vendor code used by a vendor that has not acquired any OUIs is subject to further study.	Vendor code, or all set to 1 in binary	Vendor code	Vendor code, or all set to 1 in binary	Vendor code	Vendor code	Vendor code, or all set to 1 in binary	Vendor code	Vendor code	Vendor code, or all set to 1 in binary
M24-M47	Model number	Vendor can assign value without informing TTC of it.	Nothing is specified	Model number	Nothing is specified	Model number	Model number	Nothing is specified	Model number	Model number	Nothing is specified

*1 In bits S6-S10, statuses are reflected when the terminal MC supports Option B. S6-S10 are all set to 0 in binary when the terminal MC does not support Option B.

*2 When the terminal-side/network-side link physically consists of multiple interfaces (i.e. when S11=1), for S2 and S6-S10 nothing is specified except for the case of Note 9 of Table 5-13/TS-1000.

5.3.2 Extension method for OAM frame

With a single fixed-length OAM frame, all OAM items are transmitted.

Future extension method for OAM frame is subject to further study.

5.3.3 OAM frame processing

5.3.3.1 OAM frame processing on the transmission side

Each bit in the F, C, S, and M areas of an OAM frame to be transmitted is defined as provided in Table 5-13/TS-1000.

The E area is provided for a frame check sequence (FCS) and consists of 8 bits. An FCS operation on the transmission side is performed using the method mentioned below. On the values in the information areas (C0-M47) excluding the preamble (F0-F7) of an OAM frame to be transmitted, an operation is performed using such a CRC-8 operation circuit as shown in Figure 5-5/TS-1000. The result of the operation is inserted into the E area (E0-E7). The method of operation is as follows: C0, C1, ..., and M47 are assigned as the factors of x^{79}, x^{78}, ..., and x^{0}, respectively. Then, the obtained polynomial is multiplied by x^{8}, and the remainder with modulo 2 (mod(2)) generated by dividing the product by the generation polynomial $x^{8} + x^{2} + x + 1$ is the result of operation. All of the registers used for remainder calculation (X0-X7 shown in Figure 5-5/TS-1000) are initially set to 0 in binary, and their values are updated as the information areas (C0-M47) are sequentially divided by the generation polynomial mentioned above. The values of the registers after operation on all information areas (C0-M47) are the operation result. Registers X7 (factor of x^{7}), X6 (factor of x^{6}), ..., and X0 (factor of x^{0}) are related to bits E0, E1, ..., and E7, respectively, and the resultant value of each register is inserted into the related bit in the 8-bit E area (E0-E7) before transmission.

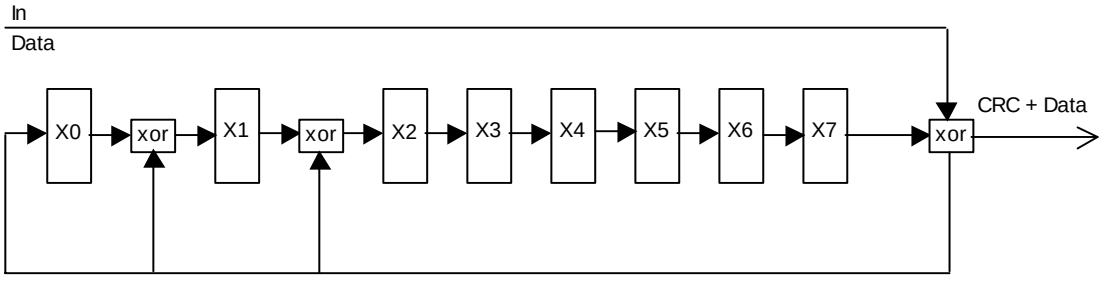


Figure 5-5/TS-1000 Example of CRC-8 operation circuit

5.3.3.2 OAM frame processing on the reception side

On the reception side, all of the registers in the CRC-8 operation circuit shown in Figure 5-5/TS-1000 are initially set to 0 in binary. Then, from the start bit (C0) in the information areas (C0-M47) of the received OAM frame, a modulo 2 remainder (mod(2)) calculation is sequentially performed using the same generation polynomial, $x^8 + x^2 + x + 1$, as used on the transmission side. By comparing the value of each register (X7-X0) after the operation on the information areas (C0-M47) and the value of the related bit in the E area (E0-E7), respectively, the validity of the received OAM frame is checked.

If the value of each register (X7-X0) after the operation on the information areas (C0-M47) of the received OAM frame is found to match the value of the related bit in the E area (E0-E7) of the OAM frame, respectively, the received OAM frame is regarded as valid, and the OAM information in the information areas (C0-M47) of that OAM frame is processed as conforming to the definitions in Table 5-13/TS-1000 and Table 5-14/TS-1000. If any mismatch is found, the received OAM frame is regarded as invalid, and the OAM information carried by that OAM frame shall not be used. Any received OAM frames shall not be transmitted toward the network or terminal shown in Figure 1-1/TS-1000 in any case.

For an OAM frame with the version area (C4-C7) set to 0000 in binary, the reception-side processing of the OAM frame carrying control signals other than those provided in Table 5-13/TS-1000, is subject to further study. When an OAM frame is received which has signals other than those provided in Table 5-14/TS-1000 in the C area (C0-C15), the OAM information in the S and M areas of that frame shall be ignored.

When an OAM frame that has signals indicating “Notify statuses/Indication (Downstream)” defined in Table 5-14/TS-1000 is received by a terminal MC not supporting Option A, the OAM information in the S and M areas of that frame shall be ignored.

In a center MC not supporting Option B, the OAM information in S6-S10 shall be ignored.

5.3.4 OAM frame transmission/reception specification

5.3.4.1 Status notification sequence

(1) Sequence of the status notification indication by the terminal MC

The sequence of the status notification indication by the terminal MC is shown in Figure 5-6/TS-1000. The terminal MC transmits a status notification indication frame to the center MC when a status change based on the state transition specification described in Section 5.3.6.1 occurs. The terminal MC may transmit a status notification indication frame once or more for a single status change. For that status change, however, the time duration from the beginning of the first status notification indication frame transmission till the end of the last status notification indication frame transmission shall be 10 μsec or less.

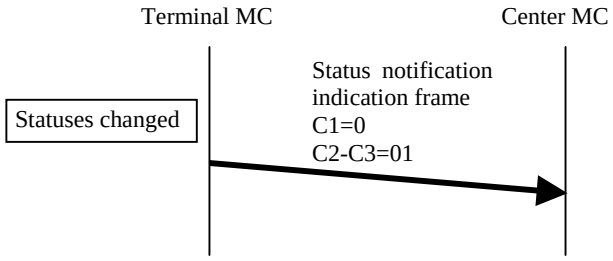


Figure 5-6/TS-1000 Sequence of the status notification indication by the terminal MC

(2) Sequence of the status notification indication by the center MC (when Option A is supported)

The sequence of the status notification indication by the center MC is shown in Figure 5-7/TS-1000. The center MC supporting Option A transmits a status notification indication frame to the terminal MC when a status change based on the state transition specification described in Section 5.3.6.2 occurs. The center MC may transmit a status notification indication frame once or more for a single status change. For that status change, however, the time duration from the beginning of the first status notification indication frame transmission till the end of the last status notification indication frame transmission shall be 10 μsec or less.

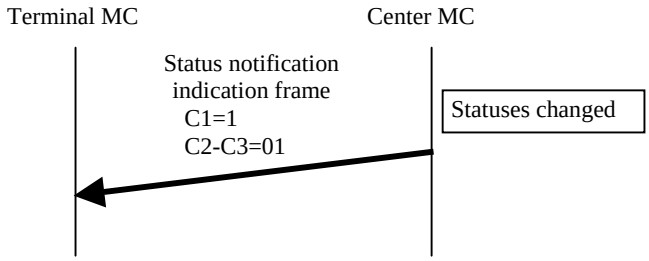


Figure 5-7/TS-1000 Sequence of the status notification indication by the center MC

(3) Sequence of the status notification request by the center MC

The sequence of the status notification request by the center MC is shown in Figure 5-8/TS-1000. The center MC transmits a status notification request frame to the terminal MC in the case of makeing a status notification request to the terminal MC. Upon reception of the status notification request frame, the terminal MC notifies its latest statuses with a status notification response frame. The terminal MC transmits a single status notification response frame for the reception of a status notification request frame.

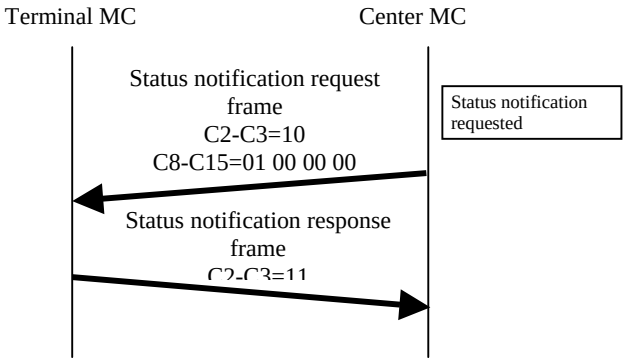


Figure 5-8/TS-1000 Sequence of the status notification request by the center MC

(4) Loop back test sequence

The loop back test sequence terminated normally and, an example of the loop back test sequence terminated abnormally are shown in Figure 5-9/TS-1000 and Figure 5-10/TS-1000, respectively.

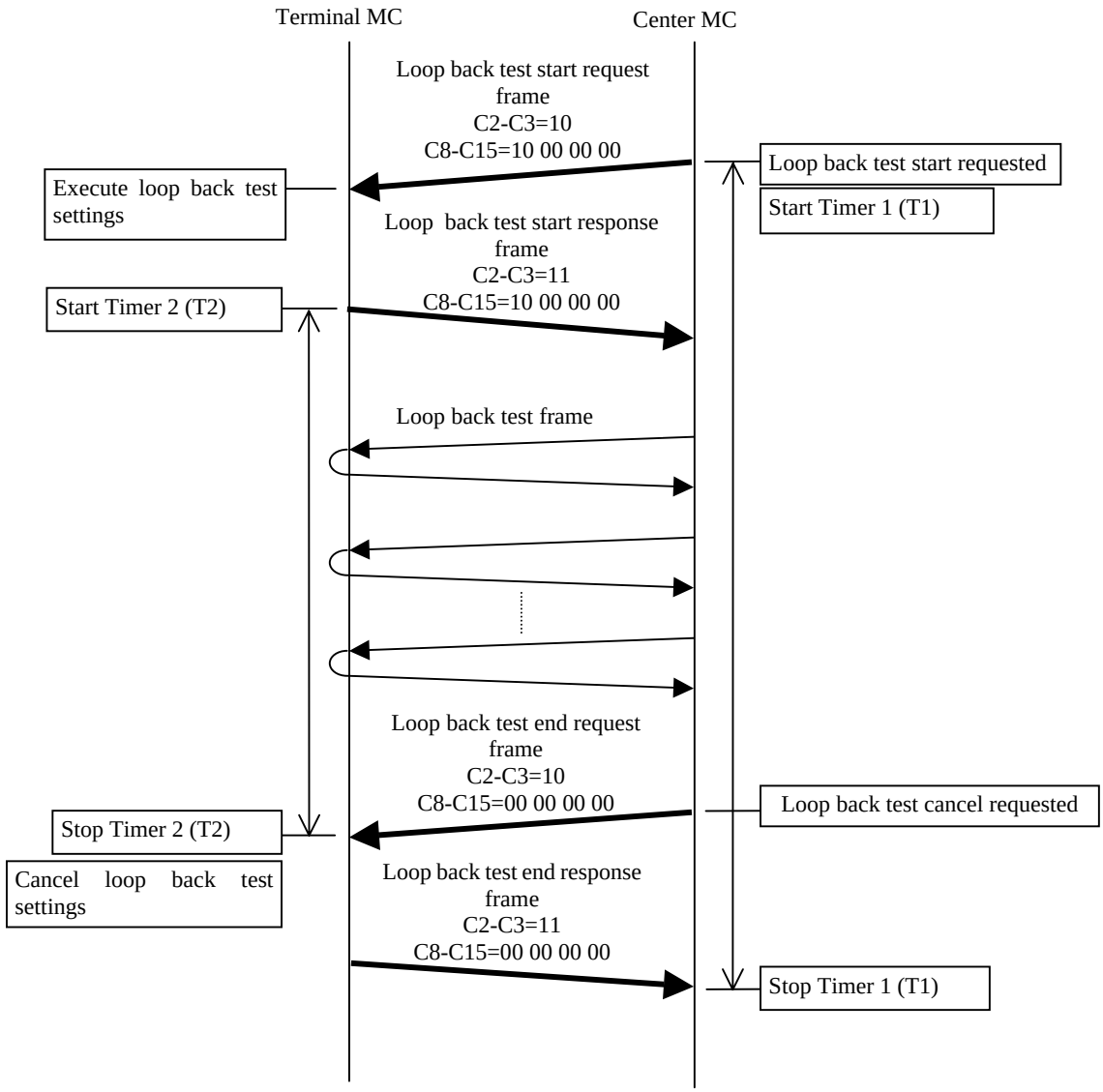


Figure 5-9/TS-1000 Loop back test sequence terminated normally

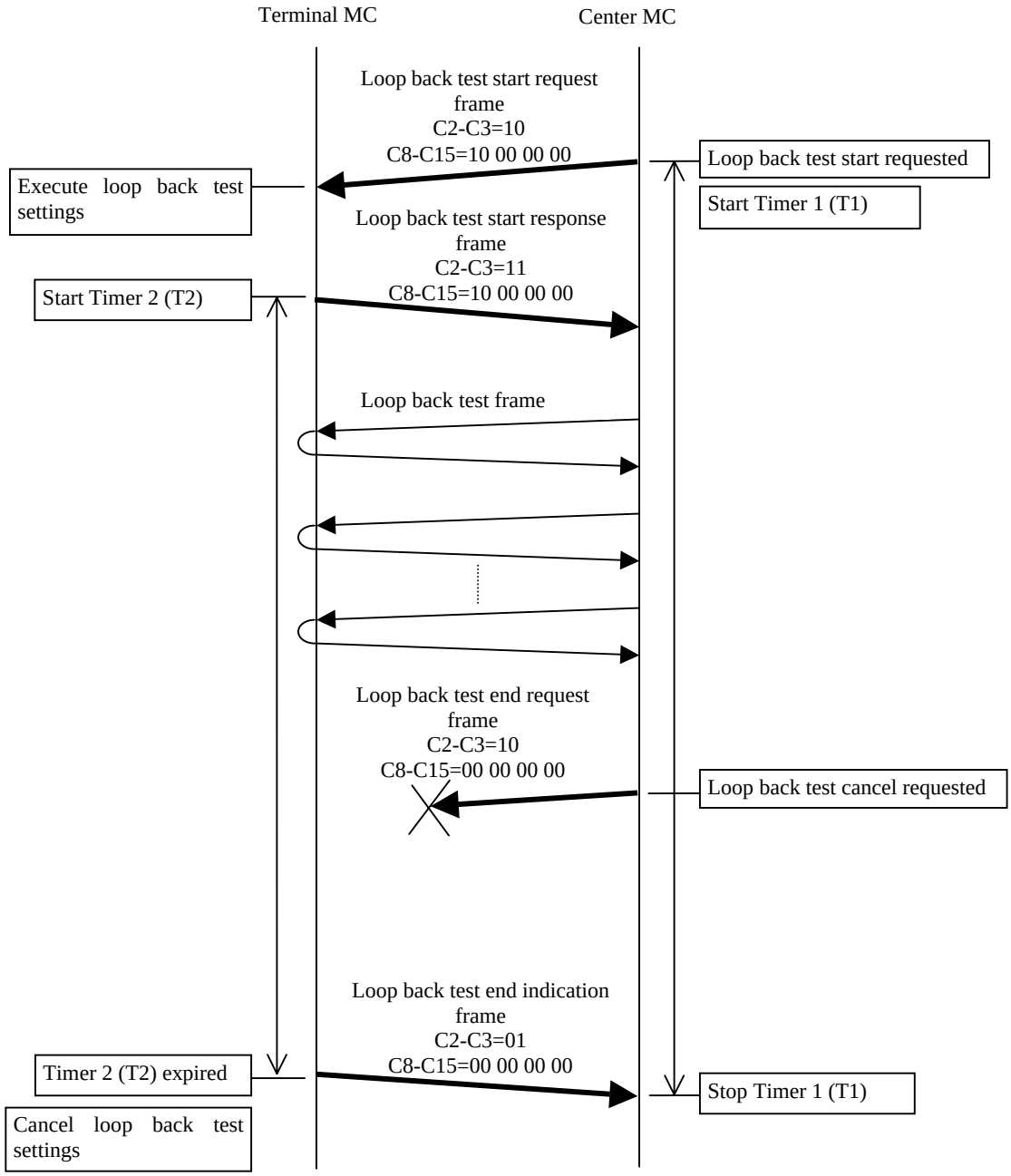


Figure 5-10/TS-1000 Example of the loop back test sequence terminated abnormally

Here, the terminal MC and center MC shall not transmit any loop back test frames toward the network or terminal shown in Figure 1-1/TS-1000.

Moreover, the center MC shall not transmit any user frames from the network toward the terminal MC during loop back test.

(a) Loop back test start sequence

Upon a loop back test start request to a center MC, the center MC starts Timer 1 (T1) after stopping user frame transmission and reception, and then transmits a loop back test start request frame (C2-C3=10, C8-C15=10 00 00 00) to the terminal MC. When the terminal MC receives the loop back test start request frame, the terminal MC starts the loop back test settings of itself. Upon completion of the settings, the terminal MC starts Timer 2 (T2),

and then transmits a loop back test start response frame (C2-C3=11, C8-C15=10 00 00 00) to the center MC. The terminal MC transmits a single loop back test start response frame for the reception of a loop back test start request frame.

Upon reception of the loop back test start response frame, the center MC is allowed to transmit loop back test frames to the terminal MC.

(b) Loop back test sequence

The center MC transmits a loop back test frame to the terminal MC, and receives the frame looped back by the terminal MC. A loop back test frame may be transmitted more than once. In this case, the time specifications for the OAM frame transmission sequence and the loop back test frame transmission interval are described in Section 5.3.6.3 and 5.3.8.4, respectively.

(c) Loop back test end sequence

The center MC transmits a loop back test end request frame (C2-C3=10, C8-C15=00 00 00 00) to the terminal MC.

Upon reception of the loop back test end request frame, the terminal MC stops Timer 2 (T2), and then cancels the loop back test settings of itself. When the cancellation of the loop back test settings is completed, the terminal MC transmits a loop back test end response frame (C2-C3=11, C8-C15=00 00 00 00) to the center MC. The terminal MC transmits a single loop back test end response frame for the reception of a loop back test end request frame.

Upon reception of the loop back test end response frame, the center MC is allowed to transmit and receive user frames.

(d) Expiry of Timer 1 (T1)

If the center MC dose not receive a loop back test start response frame or a loop back test end response frame in response to the preceding request frame, the center MC cancels the loop back test settings upon Timer 1 (T1) expiary. At this time, the center MC does not transmit a loop back test end request frame to the terminal MC.

(e) Expiry of Timer 2 (T2)

If the terminal MC dose not receive a loop back test end request frame, the terminal MC cancels the loop back test settings upon Timer 2 (T2) expiary, and transmits a loop back test end indication to the center MC. The terminal MC may transmit a loop back test end indication frame once or more upon Timer 2 (T2) expiry. For that Timer 2 (T2) expiry, however, the time duration from the beginning of the first loop back test end indication frame transmission till the end of the last loop back test end indication frame transmission shall be 10 μsec or less.

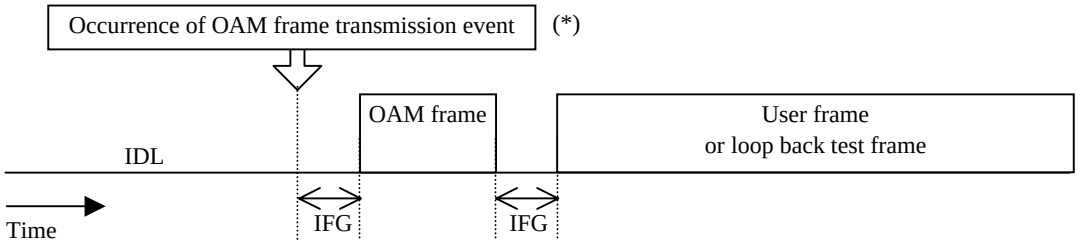
5.3.4.2 OAM frame insertion location

An OAM frame is inserted in one of two cases:

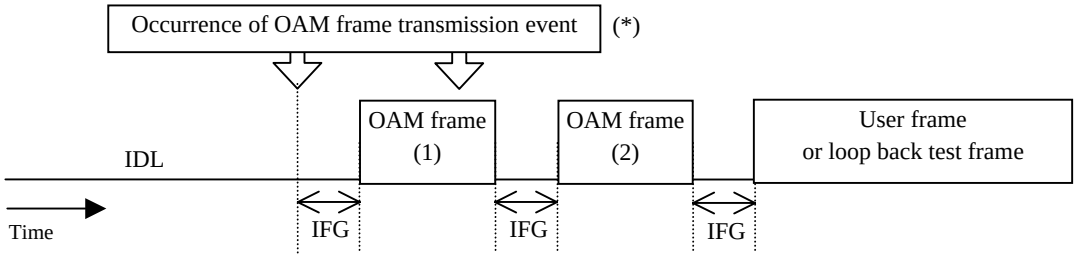
- When neither a user frame nor a loop back test frame is being transmitted
- When a user frame or loop back test frame is being transmitted

The OAM frame insertion locations applicable when neither a user frame nor a loop back test frame is being transmitted, and when a user frame or loop back test frame is being transmitted are shown in Figure 5-11/TS-1000 and Figure 5-12/TS-1000, respectively.

In both of Figure 5-11/TS-1000 and Figure 5-12/TS-1000, a case where no successive OAM frame transmission events occur, and a case where successive OAM frame transmission events occur are as shown in (a) and (b), respectively.



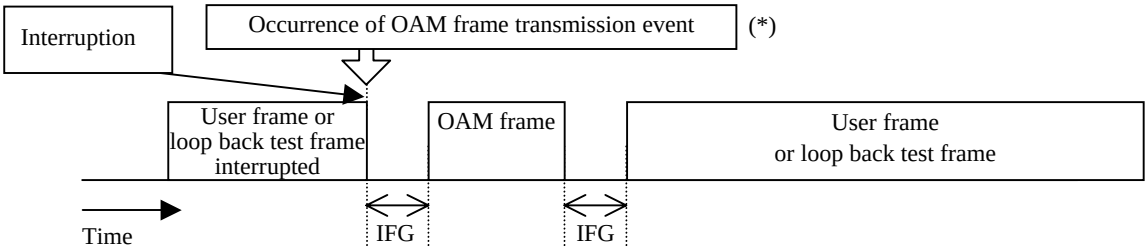
(a) When no successive OAM frame transmission events occur



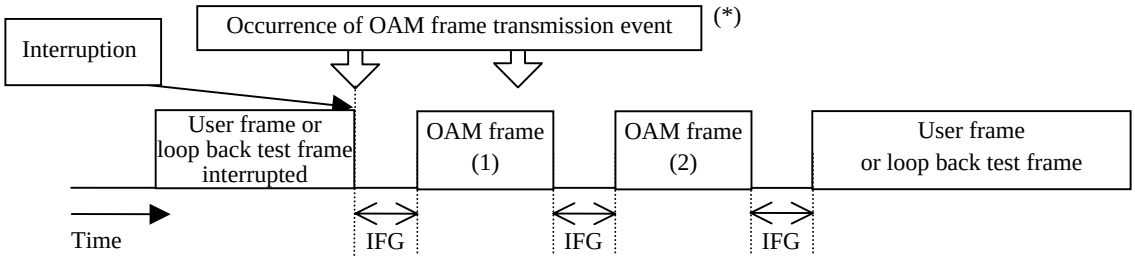
(b) When successive OAM frame transmission events occur

* This Figure does not specify the detailed timing relationship between the time when an OAM frame transmission event occurs and the time when an OAM frame transmission is started.

Figure 5-11/TS-1000 OAM frame insertion locations applicable when neither a user frame nor a loop back test frame is being transmitted



(a) When no successive OAM frame transmission events occur



(b) When successive OAM frame transmission events occur

* This Figure does not specify the detailed timing relationship between the time when an OAM frame transmission event occurs and the time when a user frame or loop back test frame transmission is interrupted.

Figure 5-12/TS-1000 OAM frame insertion locations applicable when a user frame or loop back test frame is being transmitted

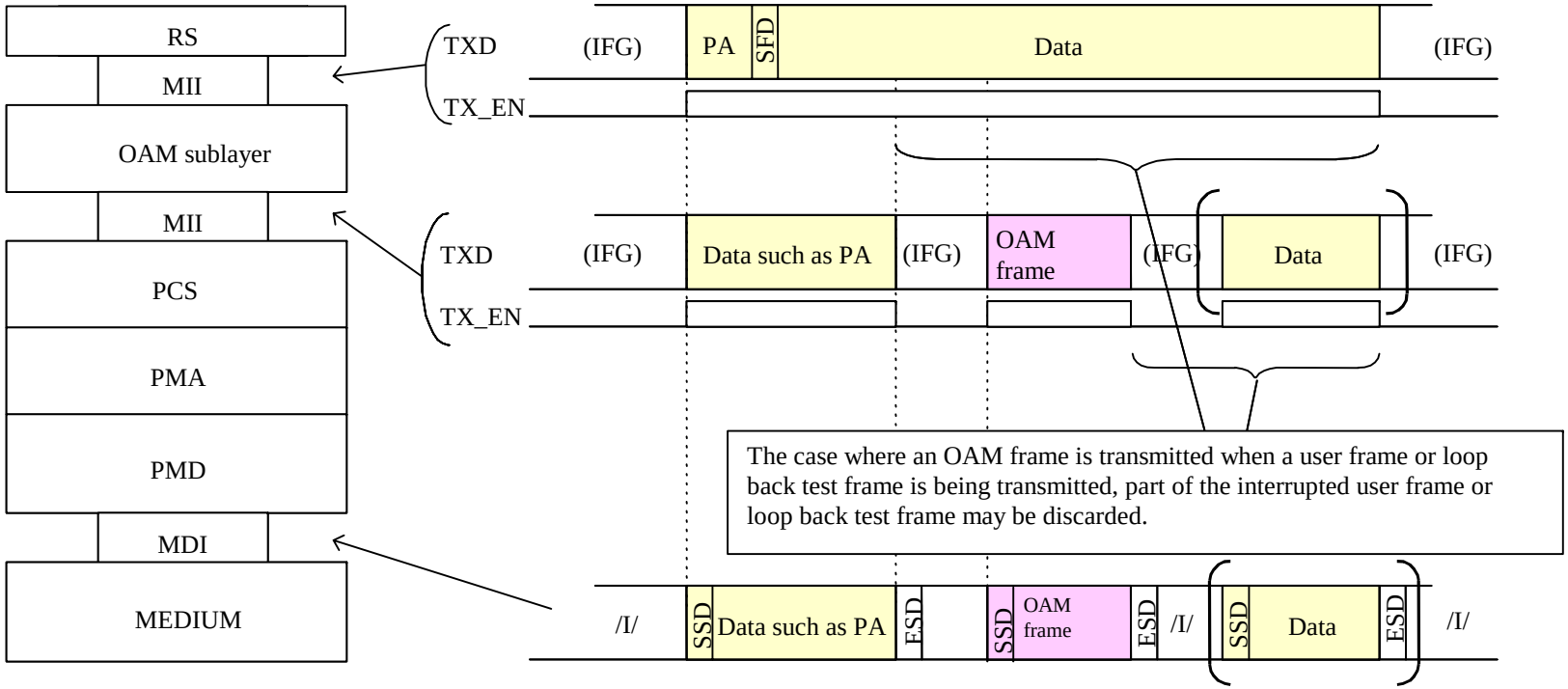
For transmission, a gap (IFG: Inter frame gap) of at least 96 bits shall be provided between a user frame or loop back test frame and an OAM frame, between two successive OAM frames, and between an OAM frame and a user frame or loop back test frame.

The handling of a user frame and loop back test frame at the time of the OAM frame transmission shall conform to the specifications below.

(1) In the case where an OAM frame is transmitted when a user frame or loop back test frame is being transmitted, part of the interrupted user frame or loop back test frame may be discarded.

(2) In the case where a user frame or loop back test frame arrives from the upper layer of the MII during OAM frame transmission, the user frame or loop back test frame may be discarded partly or entirely.

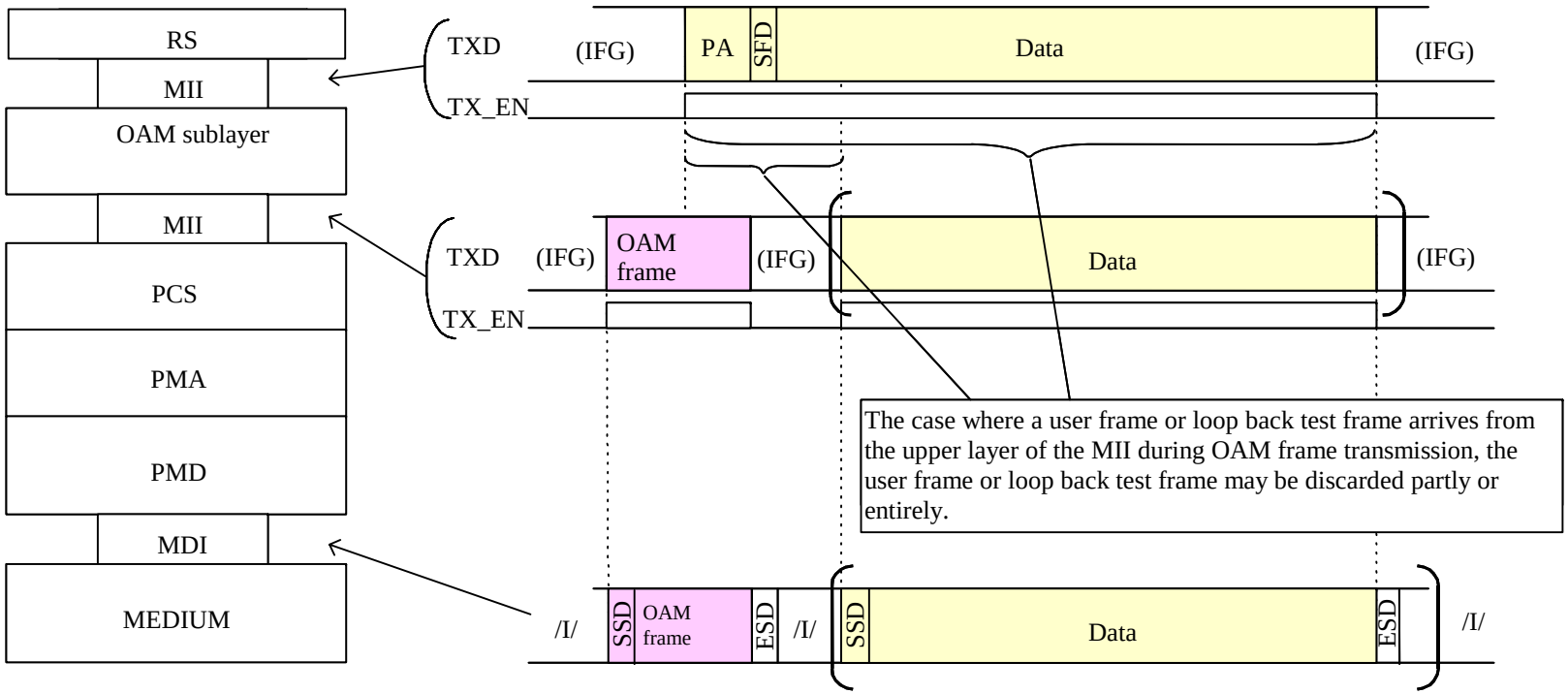
An example of discarding part of a interrupted user frame or loop back test frame in the case (1) above, and an example of discarding partly or entirely a user frame or loop back test frame arriving from the upper layer of the MII in the case (2) above, are as shown in Figure 5-13/TS-1000 and Figure 5-14/TS-1000, respectively. To the end of the interrupted user frame or loop back test frame, an end of stream delimiter (ESD) is added by the physical coding sublayer (PCS).



RS = Reconciliation sublayer
MII = Media independent interface
PCS = Physical coding sublayer
PMA = Physical medium attachment
PMD = Physical medium dependent
MDI = Medium dependent interface

IFG = Inter frame gap
PA = Preamble
SFD = Start frame delimiter
SSD = Start of stream delimiter
ESD = End of stream delimiter
/I/ = Idle code-group

Figure 5-13/TS-1000 Example of discarding part of a interrupted user frame or loop back test frame in the case (1)



RS = Reconciliation sublayer
MII = Media independent interface
PCS = Physical coding sublayer
PMA = Physical medium attachment
PMD = Physical medium dependent
MDI = Medium dependent interface

IFG = Inter frame gap
PA = Preamble
SFD = Start frame delimiter
SSD = Start of stream delimiter
ESD = End of stream delimiter
/I/ = Idle code-group

Figure 5-14/TS-1000 Example of discarding partly or entirely a user frame or loop back test frame arriving from the upper layer of the MII in the case (2)

5.3.4.3 Transmitting condition

The transmitting condition conforms to the OAM frame insertion location specifications provided in Section 5.3.4.2 and the state transition specifications provided in Section 5.3.6. Multiple changes in the statuses may be notified simultaneously.

5.3.4.4 Receiving condition

An OAM frame transmitted according to the OAM frame insertion location specifications provided in Section 5.3.4.2 shall be received. If multiple changes in the statuses are notified simultaneously, all of the changes shall be received.

From a terminal MC receives a request by the center MC until the terminal MC transmits the response to that request, the terminal MC may receive or ignore other requests. This means that if the center MC transmits the next request to the terminal MC before the center MC receives the response to the previous request to that terminal MC or before the "center MC response wait period (E)" described in Section 5.3.6.3 elapses, that next request is not necessarily effective in the terminal MC.

5.3.5 Status notification

The status notification indication sequences for the autonomous notification by the terminal MC and, by the center MC supporting Option A are shown in Figure 5-6/TS-1000, and Figure 5-7/TS-1000, respectively. The status notification request sequence, where the center MC transmits a request to a terminal MC and the terminal MC responds to that request, is shown in Figure 5-8/TS-1000.

In the autonomous notification by the terminal MC, the terminal MC notifies the center MC autonomously with a status notification indication frame if a change occurs in the statuses monitored internally by the terminal MC.

In the autonomous notification by the center MC supporting Option A, the center MC notifies the terminal MC autonomously with a status notification indication frame if a change occurs in the statuses monitored internally by the center MC.

In the case where the terminal MC responds to an request made by the center MC, the center MC requests the statuses of the terminal MC with a status notification request frame. Upon reception of the status notification request frame, the terminal MC notifies the internally monitored statuses to the center MC with a status notification response frame.

In the case where the terminal MC responds to a loop back test start request made by the center MC, the terminal MC notifies the internally monitored statuses to the center MC with a loop back test start response frame.

In the case where the terminal MC responds to a loop back test end request made by the center MC, the terminal MC notifies the internally monitored statuses to the center MC with a loop back test end response frame.

In the case where the center MC transmits a loop back test start request frame to the terminal MC and Timer 2 (T2) expires in the terminal MC, the terminal MC notifies the internally monitored statuses to the center MC with a loop back test end indication frame.

The items to be notified (i.e. status notification items) are provided in Table 5-15/TS-1000. Some of these items indicate the physical layer statuses of the terminal MC and of the center MC supporting Option A. Status notification items are notified in the cases of a status notification indication (upstream), status notification response, loop back test start response, loop back test end response, or loop back test end indication. In a status notification indication (downstream), status notification request, loop back test start request, or loop back test end request, the vendor code area (M0-M23) shall be set to a vendor code or to all 1 in binary.

"Set rate of the terminal-side link", "set duplex communication status of the terminal-side link", and "set status of automatic negotiation function of the terminal-side link" are statuses notified when Option B is supported (i.e. Option B statuses), that can be notified in the cases of a status notification indication (upstream), status notification response, loop

back test start response, loop back test end response, or loop back test end indication. Whether the terminal MC has the function of setting the Option B statuses shall be set as S6 (“support for notification of set statuses for the terminal-side link” (Option B)) in a status notification indication (upstream), status notification response, loop back test start response, loop back test end response, or loop back test end indication.

Table 5-15/TS-1000 Items to be notified (Status notification items)

Bit position	Item	Description
S0	Power supply status	Indicates the power supply status of the terminal MC. The status where regular power is supplied to the terminal MC is "normal". The status where the terminal MC is inoperative because regular power is not supplied to the terminal MC, is "power supply failure". 0: Normal 1: Power supply failure
S1	Status of the received optical signal	Indicates the status of the optical signal received, with the optical interface defined in this Technical Specification, by the terminal MC or center MC. The status where the terminal MC or center MC is receiving an optical signal is "normal". The status where no optical signal can be detected by the terminal MC or center MC is "abnormal". 0: Normal 1: Abnormal
S2	Terminal-side/network-side link status	Indicates the terminal-side link status of the terminal MC or the network-side link status of the center MC, when the terminal-side link of the terminal MC or the network-side link of the center MC physically consists of a single interface. The status where the terminal MC or center MC recognizes its destination MC and is ready to transmit and receive user frames is "established". The status where the terminal MC or center MC does not recognize its destination MC or where the terminal MC or center MC is not ready to transmit or receive user frames although that MC recognizes its destination MC, is "unestablished or disconnected". 0: Established 1: Unestablished or disconnected
S3	MC status	Indicates whether a failure is detected by the terminal MC or center MC. Here, the cases where the "power supply status" is "power supply failure", where the "status of the received optical signal" is "abnormal", and where "terminal-side/network-side link status" is "unestablished or disconnected", are excepted from the "failure". 0: Normal 1: Failure
S4	Loss-of-optical-signal notification method	Indicates whether the terminal MC uses an OAM frame or a far end fault indication (FEFI) alarm for the notification of an "abnormal" status of the received optical signal. The terminal MC notifies its "loss-of-optical-signal notification method" to the center MC. 0: With OAM frame 1: With alarm FEFI

S5	Operation status	Indicates the operation status of the terminal MC. The status where the terminal MC is ready to receive a loop back test frame from the center MC is “under loop back test”. The status where the terminal MC is allowed to transmit and receive user frames is “under ordinary operation”. 0: Under ordinary operation 1: Under loop back test
S6	Support for notification of set statuses for the terminal-side link (Option B)	Indicates whether the terminal MC supports Option B which enables the notification of the “set rate of the terminal-side link” (S7-S8), “set duplex communication status of the terminal-side link” (S9), and “set status of automatic negotiation function of the terminal-side link” (S10). 0: Not supported. 1: Supported.
S7-S8	Set rate of the terminal-side link	Indicates set rate of the terminal-side link of the terminal MC when the terminal MC supports Option B. “10 Mbit/s” shall be set when set rate of the terminal-side link is 10 Mbit/s. “100 Mbit/s” shall be set when the set rate is 100 Mbit/s. “1 Gbit/s” shall be set when the set rate is 1 Gbit/s. “Others” shall be set for other rates. When Option B is not supported, this item shall be set to 00 in binary. When the terminal-side link is “unestablished or disconnected”, nothing is specified for the values of S7-S8. 00: 10 Mbit/s 01: 100 Mbit/s 10: 1 Gbit/s 11: Others
S9	Set duplex communication status of the terminal-side link	Indicates whether the communication mode of the terminal-side link of the terminal MC is set to full duplex or half duplex, when the terminal MC supports Option B. For this item, nothing is specified when the set rate of the terminal-side link (S7-S8) is set to 11 in binary. When the terminal MC does not support Option B, this item shall be set to 0 in binary. When the terminal-side link is “unestablished or disconnected”, nothing is specified for the value of S9. 0: Half duplex 1: Full duplex
S10	Set status of automatic negotiation function of the terminal-side link	Indicates whether the automatic negotiation function of the terminal-side link of the terminal MC is enabled when the terminal MC supports Option B. The status where the automatic negotiation function is enabled, is represented by “enabled”. The status where the automatic negotiation function is disabled, is represented by “disabled”. When the terminal MC does not support Option B, this item shall be set to 0 in binary. For this item, nothing is specified when the set rate of the terminal-side link (S7-S8) is set to 11 in binary. 0: Disabled 1: Enabled
S11	Number of physical interfaces making up the terminal-side/network-side link	Indicates the number of physical interfaces making up the terminal-side link of the terminal MC or the network-side link of the center MC. 0: One 1: Greater than one

M0-M23	Vendor code	Indicates the vendor code of an MC that transmits an OAM frame. A vendor code consists of the 1st through 24th bits of an OUI of the vendor who is the supplier of that MC. The vendor code used by a vendor that has not acquired any OUIs is subject to further study.
M24-M47	Model number	Indicates the model number of the terminal MC. A model number shall be a 24-bit identifier determined by a vendor arbitrarily. A model number may consist of a device identifier, device version, and serial number.

Note 1) When the terminal-side link of the terminal MC/network-side link of the center MC physically consists of multiple interfaces, for S2 and S6-S10 nothing is specified except for the case of Note 9 of Table 5-13/TS-1000.

Note 2) "Set statuses for the terminal-side link" (S7-S10) notified by a terminal MC supporting Option B, shall be the set statuses which are used for the link establishment of "the terminal-side link of the terminal MC" just before that status notification.

5.3.6 State transition

5.3.6.1 State diagram of the terminal MC

In Table 5-16/TS-1000, a state diagram of the terminal MC is provided in the cases of the reception of an alarm (network-side link status is “unestablished or disconnected”) or a failure (status of the received optical signal is “abnormal”, and MC link status is “failure” in order of priority) detection by the center MC, the detection of an alarm (terminal-side link status is “unestablished or disconnected”) or a failure (power supply status is “failure”, status of the received optical signal is “abnormal”, and MC status is “failure” in order of priority) by the terminal MC, the loop back test, changes in the set statuses of the terminal-side link when Option B is supported, and the reception of a status notification request. The following states are defined in the state diagram:

UST0

Ordinary operation

State where the terminal MC is started but is not engaged in loop back test.

When a loop back test start request by the center MC is received, a transition is made to the “under loop back test” state (UST1). The flow of the state transition in this case is shown in Figure 5-15/TS-1000.

At the time of alarm detection or recovery, the terminal MC statuses are notified with a status notification indication frame.

At the time of failure detection or recovery, the terminal MC statuses are notified with a status notification indication frame. At the time of recovery from a “power supply failure”, however, a state transition may be made to the ordinary operation state (UST0), or no status notification indication frame may be transmitted. If Option B is supported, the terminal MC statuses are notified with a status notification indication frame when a change in the set statuses of the terminal-side link is detected.

When a status notification request frame is received, the terminal MC statuses are notified with a status notification response frame.

UST1

Under loop back test

State where a signal received through the optical interface is looped back and transmitted through the same optical interface, upon reception of a loop back test start request frame. When a loop back test end request frame is received or Timer 2 (T2) expires, a state transition is made to the ordinary operation state (UST0). The flow of the state transition in this case is shown in Figure 5-16/TS-1000.

At the time of failure detection or recovery, the terminal MC statuses are notified with a status notification indication frame. At the time of recovery from a “power supply failure”, however, a state transition may be made to the ordinary operation state (UST0), or no status notification indication frame may be transmitted. If Option B is supported, the terminal MC statuses are notified with a status notification indication frame when a change in the set statuses of the terminal-side link is detected.

When a status notification request frame is received, the terminal MC statuses are notified with a status notification response frame.

In the “under loop back test” state (UST1), neither upstream user frame transmission nor downstream user frame reception is allowed.

5.3.6.2 State diagram of the center MC

In Table 5-17/TS-1000, a state diagram of the center MC is provided in the cases of the reception of an alarm (terminal-side link status is “unestablished or disconnected”) or a failure (power supply status is “failure”, status of the

received optical signal is “abnormal”, and MC status is “failure” in order of priority) detection by the terminal MC, the detection of an alarm (network-side link status is “unestablished or disconnected”) or a failure (status of the received optical signal is “abnormal”, and MC status is “failure” in order of priority) by the center MC, and the loop back test.

The following states are defined in the state diagram:

CST0

Ordinary operation

State where the center MC is started but is not engaged in loop back test or is not making a loop back test request.

At the time of alarm or failure detection or recovery, the center MC which is supporting Option A notifies its statuses with a status notification indication frame.

CST1

Under loop back test

State from the reception of a loop back test start response by the terminal MC in the “loop back test request in progress” state (CST2) until a state transition is made to the ordinary operation state (CST0) upon reception of a loop back test end response by that terminal MC. A state transition is made to the ordinary operation state (CST0) when a loop back test end indication by the terminal MC is received or Timer 1 (T1) expires.

A status notification request during loop back test is not prohibited.

At the time of failure detection or recovery, the center MC which is supporting Option A notifies its statuses with a status notification indication frame.

In the “under loop back test” state (CST1), neither upstream user frame reception nor downstream user frame transmission is allowed.

CST2

Loop back test request in progress

State from the transmission of a loop back test start request to the terminal MC in the ordinary operation state (CST0) until a state transition is made to the “under loop back test” state (CST1) upon reception of a loop back test start response by that terminal MC.

A state transition is made to the ordinary operation state (CST0) when a loop back test end indication by the terminal MC is received or Timer 1 (T1) expires. When a loop back test end response by the terminal MC is received, the center MC stops Timer 1 (T1), and a state transition is made to the ordinary operation state (CST0).

At the time of failure detection or recovery, the center MC which is supporting Option A notifies its statuses with a status notification indication frame.

In the “loop back test request in progress” state (CST2), no downstream user frame transmission is allowed, and for an upstream user frame reception nothing is specified.

Table 5-16/TS-1000 State diagram of the terminal MC

State identifier / Event / State name	UST0	UST1
	Ordinary operation	Under loop back test
Initialization completed (*1)	UST0	UST0
Loop back test start request frame received	Start Timer 2 (T2) Transmit loop back test start response frame UST1 (*2), (*3)	Restart Timer 2 (T2) Transmit loop back test start response frame (*2), (*3)
Loop back test end request frame received	Transmit loop back test end response frame (*2), (*4)	Stop Timer 2 (T2) Transmit loop back test end response frame UST0 (*2), (*4)
Timer 2 (T2) Expired	/	Transmit loop back test end indication frame UST0 (*2), (*4)
Failure detected	Transmit status notification indication frame	Transmit status notification indication frame
Failure recovered (*5)	Transmit status notification indication frame	Transmit status notification indication frame
Alarm detected	Transmit status notification indication frame	-
Alarm recovered	Transmit status notification indication frame	-
Failure detection received, or failure recovery received (*6)	-	-
Alarm detection received, or alarm recovery received (*6)	-	-
Set statuses for the terminal side link changed (*7)	Transmit status notification indication frame	-
Status notification request frame received	Transmit status notification response frame	Transmit status notification response frame

Legend: "-": No state transition

"/": Event that cannot occur

*1 Upon completion of initialization, a status notification indication frame may be transmitted.

*2 A loop back test start response frame, loop back test end response frame, or loop back test end indication frame carrying the latest statuses of the terminal MC is transmitted.

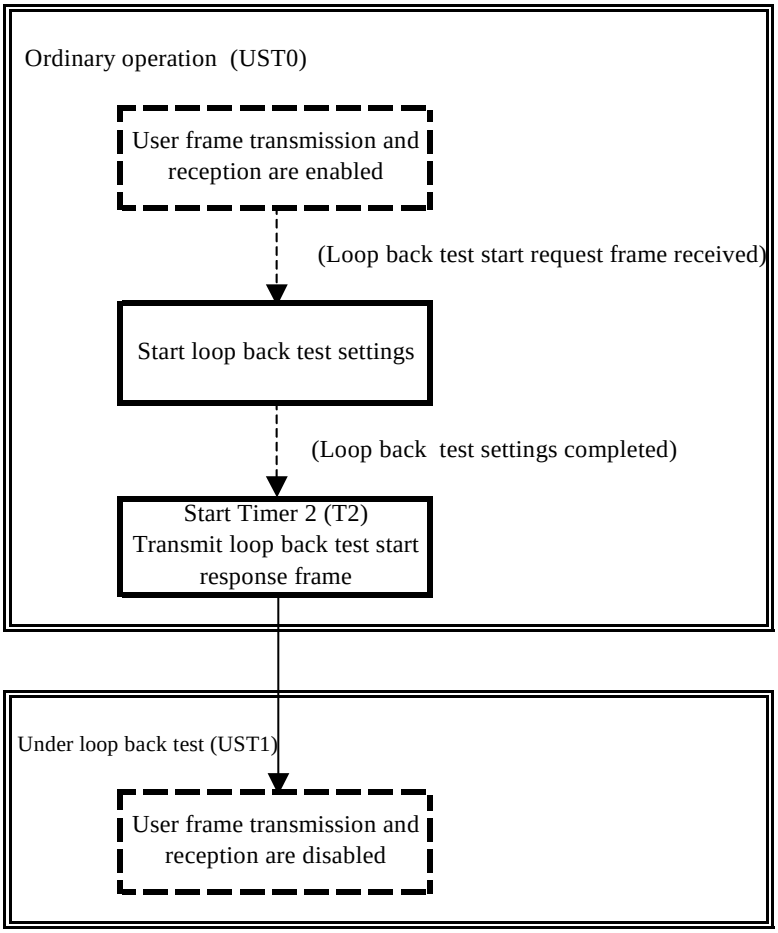
*3 After the loop back test settings are completed by the terminal MC, a loop back test start response frame is transmitted.

*4 After the loop back test settings cancellation is completed by the terminal MC, a loop back test end response frame or loop back test end indication frame is transmitted.

*5 At the time of recovery from a “power supply failure”, a state transition may be made to the ordinary operation state (UST0) or no status notification indication frame may be transmitted.

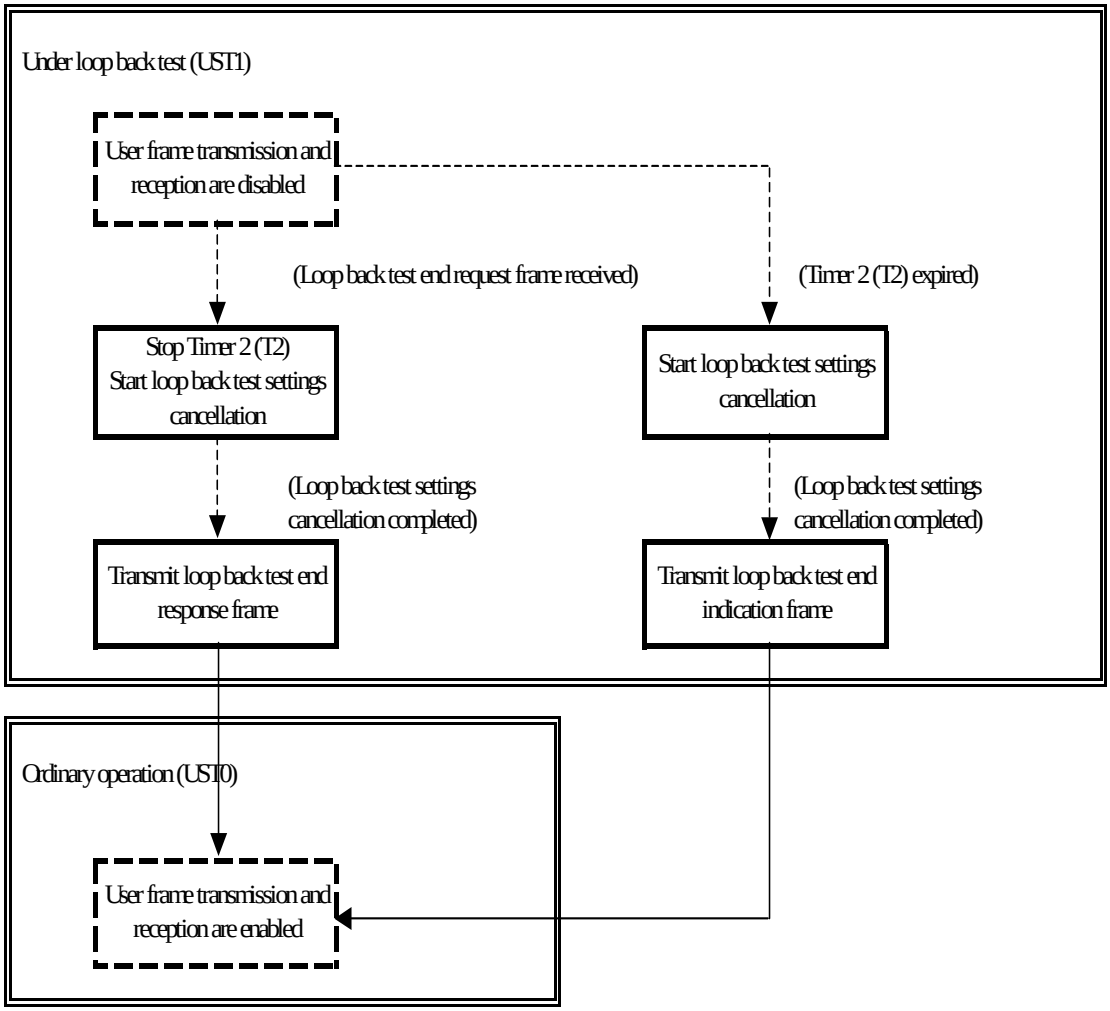
*6 Ignored when Option A is not supported.

*7 Ignored when Option B is not supported.



Note 1) The loop back test settings include disabling user frame transmission and reception, and enabling loop back of loop back test frames.
Note 2) User frames in the terminal MC during the loop back test settings may be discarded.
Note 3) For the user frame transmission and reception during the state transitions, nothing is specified.
Note 4) In the figure, ▭ represents a state, ▭ represents a terminal MC operation, and an item in ( ) indicates a operating condition.

Figure 5-15/TS-1000 Flow of state transition from the ordinary operation state (UST0) to the “under loop back test” state (UST1)



Note 1) The loop back test settings cancellation includes enabling user frame transmission and reception, and disabling loop back of loop back test frames.
Note 2) User frames in the terminal MC during the loop back test settings cancellation or at the expiry of Timer 2 (T2) may be discarded.
Note 3) For the user frame transmission and reception during the state transitions, nothing is specified.
Note 4) In the figure, ▣ represents a state, ▭ represents a terminal MC operation, and an item in ( ) indicates a operating condition.

Figure 5-16/TS-1000 Flow of state transition from the "under loop back test" state (UST1) to the ordinary operation state (UST0)

Table 5-17/TS-1000 State diagram of the center MC

State identifier / State name / Event	CST0	CST1	CST2
	Ordinary operation	Under loop back test	Loop back test request in progress
Initialization completed	CST0	CST0	CST0
Loop back test start requested	Start Timer 1 (T1) Transmit loop back test start request frame CST2	-	- (*1)
Loop back test end requested	-	Transmit loop back test end request frame	Transmit loop back test end request frame
Loop back test start response frame received	- (*3)	- (*3)	CST1
Loop back test end response frame received	- (*3)	Stop Timer 1 (T1) CST0	Stop Timer 1 (T1) CST0
Loop back test end indication frame received	- (*3)	Stop Timer 1 (T1) CST0	Stop Timer 1 (T1) CST0
Timer 1 (T1) expired	/	CST0 (*2)	CST0 (*2)
Failure detected	Transmit status notification indication frame (*4)	Transmit status notification indication frame (*4)	Transmit status notification indication frame (*4)
Failure recovered	Transmit status notification indication frame (*4)	Transmit status notification indication frame (*4)	Transmit status notification indication frame (*4)
Alarm detected	Transmit status notification indication frame (*4)	-	-
Alarm recovered	Transmit status notification indication frame (*4)	-	-
Failure detection received, or failure recovery received	-	-	-
Alarm detection received, or alarm recovery received	-	-	-

Legend: "-": No state transition

"/": Event that cannot occur

*1 Timer 1 (T1) may be restarted, and then a loop back test start request frame may be transmitted.

*2 At the expiry of Timer 1 (T1), no loop back test end request frame is transmitted.

*3 Event that does not occur usually.

*4 Only when Option A is supported.

5.3.6.3 Time specifications for OAM frame transmission sequence

The time specifications for the OAM frame transmission sequence of status notification request by the center MC to the terminal MC, and of loop back test are defined below.

The time specifications for the OAM frame transmission sequence are as shown in Figure 5-17/TS-1000. The time values related to the OAM frame transmission sequence are provided in Table 5-18/TS-1000.

(A) Center MC user frame blocking period

To protect against congestion due to multiple user frame arrivals during loop back test, a period of time, in which user frame transmission and reception by the center MC are prohibited, shall be specified. However, when the center MC receives a loop back test end response or a loop back test end indication by the terminal MC, user frame transmission and reception by the center MC shall be immediately allowed.

(B) Terminal MC response return period

A period of time between the instant when the terminal MC receives a status notification request, loop back test start request, or loop back test end request by the center MC and the instant when the terminal MC transmits a response to that request to the center MC, shall be specified. For the loop back test start request and loop back test end request, this period shall include a period of time required for the completion of the loop back test settings and those cancellation, respectively.

(C) Terminal MC “under loop back test” state guarantee period

A period of time in which the terminal MC must preserve loop back test settings after the transmission of a loop back test start response, shall be specified. However, when a loop back test end request by the center MC is received, the loop back test settings may be immediately cancelled.

(D) Terminal MC “under loop back test” state allowance period

A period of time in which the disabling of user frame transmission and reception by the terminal MC is allowed in loop back test, shall be specified.

(E) Center MC response wait period

A period of time in which, after the center MC transmits a status notification request, loop back test start request, or loop back test end request to the terminal MC, the center MC is waiting for a response to that request from the terminal MC, shall be specified. However, when a response to the preceding request is received within the specified “center MC response wait period” (E), that “center MC response wait period” (E) is assumed to have elapsed. The center MC may transmit a following request before the specified “center MC response wait period” (E) elapses. In this case, however, the reception of such a request by the terminal MC is not guaranteed.

(F) Center MC loop back test allowance period

A period of time in which loop back test frame transmission by the center MC is allowed in a loop back test after the center MC receives the loop back test start response for that loop back test from the terminal MC, shall be specified.

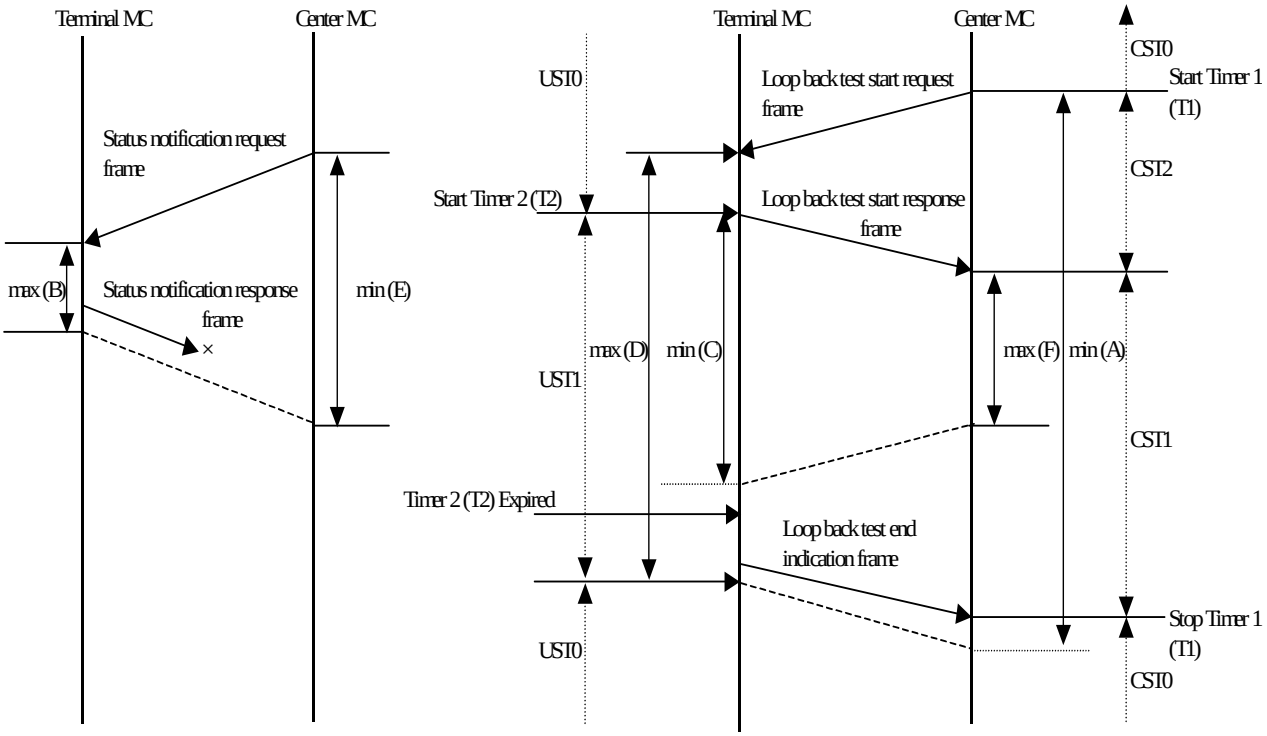


Figure 5-17/TS-1000 Time specifications for the OAM frame transmission sequence

Table 5-18/TS-1000 Time values related to the OAM frame transmission sequence

Item for a period of time	Minimum value (min)	Maximum value (max)	Remarks
(A) Center MC user frame blocking period	2010 ms	-	min (A) = max (D) + 10 ms
(B) Terminal MC response return period	-	600 ms	
(C) Terminal MC "under loop back test" state guarantee period	900 ms	-	
(D) Terminal MC "under loop back test" state allowance period	-	2000 ms	
(E) Center MC response wait period	610 ms	-	min (E) = max (B) + 10 ms
(F) Center MC loop back test allowance period	-	890 ms	max (F) = min (C) - 10 ms

5.3.7 Status notification indication processing

If a status change that can make communication discontinued or restarted occurs in the terminal MC, the terminal MC shall notify its statuses to the center MC with a status notification indication frame. If a status change that can make communication discontinued or restarted occurs in the center MC supporting Option A, the center MC shall notify its statuses to the terminal MC with a status notification indication frame. The terminal MC or the center MC supporting Option A may transmit a status notification indication frame once or more for a single status change. For that status change, however, an IFG of 96 bits or more shall be provided between any two successive status notification indication frames. In addition, the time duration from the beginning of the first status notification indication frame transmission till the last status notification indication frame transmission shall be 10 μsec or less.

5.3.7.1 Status changes notified by the terminal MC to the center MC

When any of the status changes below occurs, the terminal MC shall transmit one or more status notification indication frames to the center MC.

(a) Change in “power supply status” into “power supply failure”

When the regular power begins not to be supplied, the terminal MC shall transmit a status notification indication frame before stopping the operation.

(b) Change in “status of the received optical signal” into “abnormal”

When the terminal MC detects a change in the “status of the received optical signal” into “abnormal”, the terminal MC shall perform one of the following operations:

- Transmission of a status notification indication frame
- Transmission of a far end fault indication (FEFI) conforming to Chapter 24 of IEEE Standard 802.3

The center MC shall be able to recognize an “abnormal” status of the received optical signal in either case.

(c) Change in “status of the received optical signal” into “normal”

When the “status of the received optical signal” returns to the “normal” status, the terminal MC shall transmit a status notification indication frame. Even if an “abnormal” status of the received optical signal is notified using an FEFI, the terminal MC shall transmit a status notification indication frame when the “status of the received optical signal” returns to the “normal” status.

(d) Change in “MC status” into “failure”

When the terminal MC detects a change in its “MC status” into “failure”, the terminal MC shall transmit a status notification indication frame.

(e) Change in “MC status” into “normal”

When the terminal MC completely recovers from the MC status “failure”, the terminal MC shall transmit a status notification indication frame.

(f) Change in “terminal-side/network-side link status” into “unestablished or disconnected”

If the terminal-side link physically consists of a single interface, the terminal MC shall transmit a status notification indication frame when a change in the “terminal-side/network-side link status” is made from “established” to “unestablished or disconnected”. If the terminal-side link physically consists of multiple interfaces, no specification is provided except for the case of Note 9 of Table 5-13/TS-1000.

(g) Change in “terminal-side/network-side link status” into “established”

If the terminal-side link physically consists of a single interface, the terminal MC shall transmit a status notification indication frame when a change in the “terminal-side/network-side link status” is made from “unestablished or disconnected” to “established”. If the terminal-side link physically consists of multiple interfaces, no specification is provided except for the case of Note 9 of Table 5-13/TS-1000.

(h) Timer 2 (T2) expired

The terminal MC, when placed in the “under loop back test” state (UST1), returns to the ordinary operation state (UST0) after a certain period of time elapses (i.e. expiry of Timer 2 (T2)) even if the terminal MC dose not receive a loop back test end request frame from the center MC. At this time, the terminal MC shall notify the status change to the center MC by transmitting a loop back test end indication frame instead of a status notification indication frame.

(i) Change in “set statuses for the terminal-side link” (when Option B is supported)

If the terminal-side link physically consists of a single interface, the terminal MC shall transmit a status notification indication frame when any of the “set statuses for the terminal-side link” indicated below is changed. If the terminal-side link physically consists of multiple interfaces, no specification is provided except for the case of Note 9 of Table 5-13/TS-1000.

- Set rate of the terminal-side link
- Set duplex communication status of the terminal-side link
- Set status of automatic negotiation function of the terminal-side link

5.3.7.2 Status changes notified by the center MC to the terminal MC (when Option A is supported)

When any of the status changes below occurs, the center MC supporting Option A shall transmit one or more status notification indication frames to the terminal MC.

(a) Change in “status of the received optical signal” into “abnormal”

When the center MC detects a change in the “status of the received optical signal” into “abnormal”, the center MC shall perform one of the following operations:

- Transmission of a status notification indication frame
- Transmission of a far end fault indication (FEFI) conforming to Chapter 24 of IEEE Standard 802.3

The terminal MC supporting Option A shall be able to recognize an “abnormal” status of the received optical signal in either case.

(b) Change in “status of the received optical signal” into “normal”

When the “status of the received optical signal” returns to the “normal” status, the center MC shall transmit a status notification indication frame. Even if an “abnormal” status of the received optical signal is notified using an FEFI, the center MC shall transmit a status notification indication frame when the “status of the received optical signal” returns to the “normal” status.

(c) Change in “MC status” into “failure”

When the center MC detects a change in its “MC status” into “failure”, the center MC shall transmit a status notification indication frame.

(d) Change in “MC status” into “normal”

When the center MC completely recovers from the MC status “failure”, the center MC shall transmit a status notification indication frame.

(e) Change in “terminal-side/network-side link status” into “unestablished or disconnected”

If the network-side link physically consists of a single interface, the center MC shall transmit a status notification indication frame when a change in the “terminal-side/network-side link status” is made from “established” to “unestablished or disconnected”. If the network-side link physically consists of multiple interfaces, no specification is provided except for the case of Note 9 of Table 5-13/TS-1000.

(f) Change in “terminal-side/network-side link status” into “established”

If the network-side link physically consists of a single interface, the center MC shall transmit a status notification indication frame when a change in the “terminal-side/network-side link status” is made from “unestablished or disconnected” to “established”. If the network-side link physically consists of multiple interfaces, no specification is provided except for the case of Note 9 of Table 5-13/TS-1000.

5.3.7.3 Exceptions to status notification indication

A status notification indication shall be made by transmitting a status notification indication frame once or more, when a status change described in Section 5.3.7.1 occurs in the terminal MC or when a status change described in Section 5.3.7.2 occurs in the center MC supporting Option A. Note that the time duration from the beginning of the first status notification indication frame transmission till the end of the last status notification indication frame transmission shall be 10 μsec or less.

However, this indication has the exceptions described below.

(a) Case where multiple status changes requiring a status notification indication occur in a short time

If a status change requiring a status notification indication is followed by another status change requiring a status notification indication before a status notification indication frame is transmitted for the former status change, the results of those multiple status changes may be notified with a single status notification indication frame.

(b) Case where a status change requiring a status notification indication occurs at about the same time as the time when a status notification request frame is received

If a status change requiring a status notification indication occurs at about the same time as the time when a status notification request frame is received, the terminal MC may notifies its latest statuses with a status notification response frame.

(c) Case where a status change occurs when the “status of the received optical signal” is “abnormal”

If an FEFI is used for the notification of an “abnormal” status of the received optical signal, no status notification indication frame may be transmitted even when a status change, requiring a status notification indication, other than into “normal” status of the received optical signal occurs in the case of the “abnormal” status of the received optical signal.

(d) Case where the “terminal-side link/network-side link status” changes to “established” or to “unestablished or disconnected” in the “under loop back test” state (UST1/CST1)

Any changes in the “terminal-side link/network-side link status” make no influence on the loop back test. Therefore, no status notification indication frame shall be transmitted, even if a change in the “terminal-side link/network-side link status” into “established” or into “unestablished or disconnected” occurs in the “under loop back test” state (UST1/CST1).

After the “loop back test settings cancellation” is completed, the terminal MC shall transmit a loop back test end indication frame or a status notification indication frame to the center MC. At this time, the latest statuses of that terminal MC shall be notified with that frame. After the completion of the loop back test, the center MC supporting Option A shall notify its latest statuses to the terminal MC by transmitting a status notification indication frame to the terminal MC.

5.3.8 Loop back test specification

5.3.8.1 Loop back test point

For a point where loop back test frames are loop backed (i.e. loop back test point), an arbitrary location may be selected in the terminal MC.

5.3.8.2 Loop back test frame format

A loop back test frame to be transmitted from the center MC shall be a MAC frame (shown in Figure I-1/TS-1000 in Appendix I) conforming to IEEE Standard 802.3.

5.3.8.3 Loop back test frame areas

The areas of the loop back test frame (i.e. loop back test frame areas) are provided in Table 5-19/TS-1000.

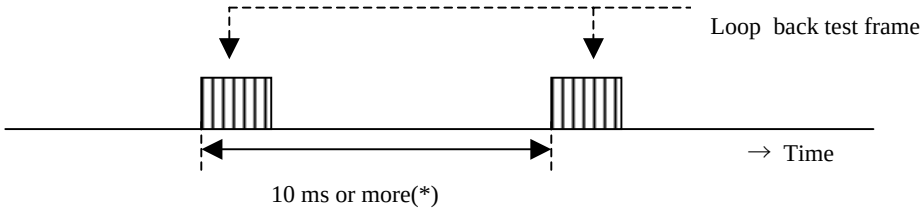
The terminal MC shall loop back all types of loop back test frames having areas provided in Table 5-19/TS-1000 without any modifications to the values in any frame areas. The center MC shall transmit at least one type of loop back test frames having areas provided in Table 5-19/TS-1000.

Table 5-19/TS-1000 Areas of loop back test frame

Area name	Specification
PREAMBLE	Conforms to IEEE Standard 802.3.
SFD	Conforms to IEEE Standard 802.3.
DESTINATION ADDRESS	Conforms to IEEE Standard 802.3. The address in this area shall be a broadcast address, or a unicast address assigned by the center MC. The address in this area shall be an address other than a SOURCE ADDRESS.
SOURCE ADDRESS	Conforms to IEEE Standard 802.3. The address in this area shall be a unicast address assigned by the center MC. The address in this area shall be an address other than a DESTINATION ADDRESS.
LENGTH/TYPE	To be used as LENGTH or TYPE conforming to IEEE Standard 802.3. When this area is used as TYPE, this area shall be set to 0800 in hexadecimal.
MAC CLIENT DATA	Conforms to IEEE Standard 802.3. The data pattern in this area may be arbitrary. This area may have an arbitrary length of 46 to 1500 octets.
PAD	
FRAME CHECK SEQUENCE	Conforms to IEEE Standard 802.3.
EXTENSION	Not to be used.

5.3.8.4 Transmission interval

The center MC may transmit a loop back test frame more than once. However, the following loop back test frame shall be transmitted 10 ms or more after the previous loop back test frame as shown in Figure 5-18/TS-1000, or after the center MC confirms the reception of the previous loop back test frame.



* Not applicable when the center MC confirms the reception of a loop back test frame

Figure 5-18/TS-1000 Loop back test frame transmission interval

Appendix I MAC frame format (conforming to IEEE Standard 802.3)

(For TTC Specification TS-1000)

The MAC frame format conforming to IEEE Standard 802.3 is shown in Figure I-1/TS-1000.

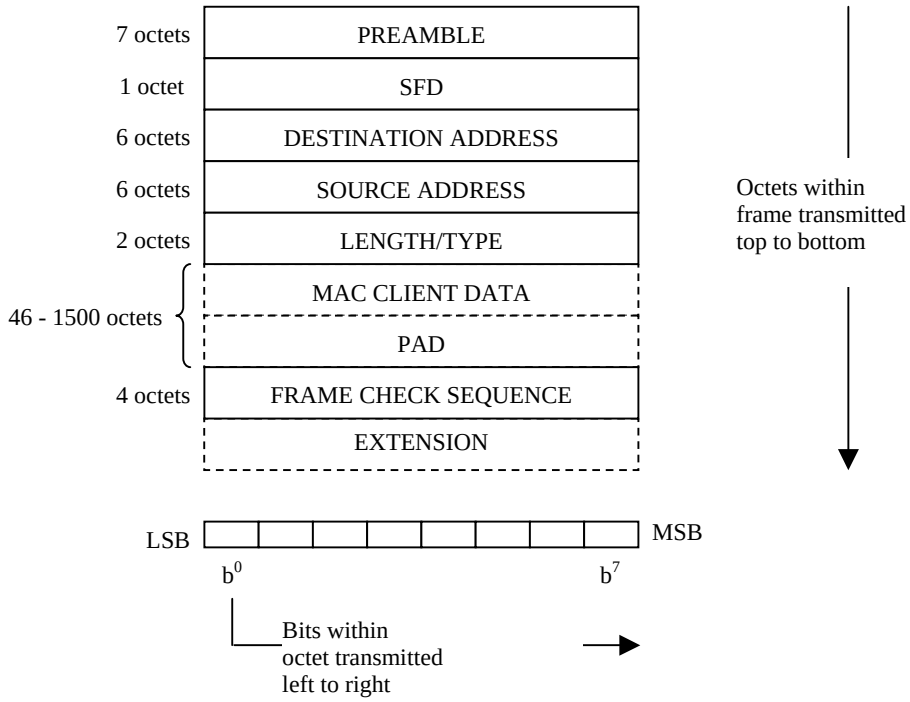


Figure I-1/TS-1000 MAC frame format

(IEEE Standard 802.3)

Appendix II Applicable distance of Class S

(For TTC Specification TS-1000)

The transmission distance depends on the chromatic dispersion characteristics of the fiber and the light source condition. When a fiber conforming to the ITU-T Recommendation G.652 is used, intersymbol interference and mode partition noise can occur due to the chromatic dispersion characteristics of the fiber and 1.55 μm-region light source condition, resulting in a restriction on the transmission distance.

In accordance with the formula specified in Annex I of TTC Standard JT-G957, the condition for suppressing the power penalty due to intersymbol interference and mode partition noise to within 1 dB is given as follows:

$0.115 \geq 10^{-6} \times$ bit rate (Mbit/s) $\times$ dispersion (ps/nm) $\times$ RMS spectral width

In this Technical Specification, the bit rate is 125 Mbit/s.

In accordance with Section 2.2 “Chromatic dispersion coefficient” of ITU-T Recommendation G.652, the maximum absolute value of a dispersion coefficient in the 1.55 μm region is calculated by the following expression:

$$\left|D_1(\lambda)\right| = \left|\frac{S_{0\max}}{4}\left[\lambda - \frac{\lambda_{0\min}^4}{\lambda^3}\right]\right|$$

In this Technical Specification, the wavelength λ that causes the expression above to produce a maximum value is 1600 nm. Moreover, Section 2.2 “Chromatic dispersion coefficient” of ITU-T Recommendation G.652 specifies $S_{0\,\max}$ = -0.093 ps/(nm^2·km) and $\lambda_{0\,\min}$ = 1300 nm. So, a maximum absolute dispersion coefficient of 20.99 ps/(nm·km) is found by calculation.

Accordingly, when the RMS spectral width is 4.6 nm, the transmission distance that can guarantee a power penalty not exceeding 1 dB is 9.6 km or less (See Figure II-1/TS-1000).

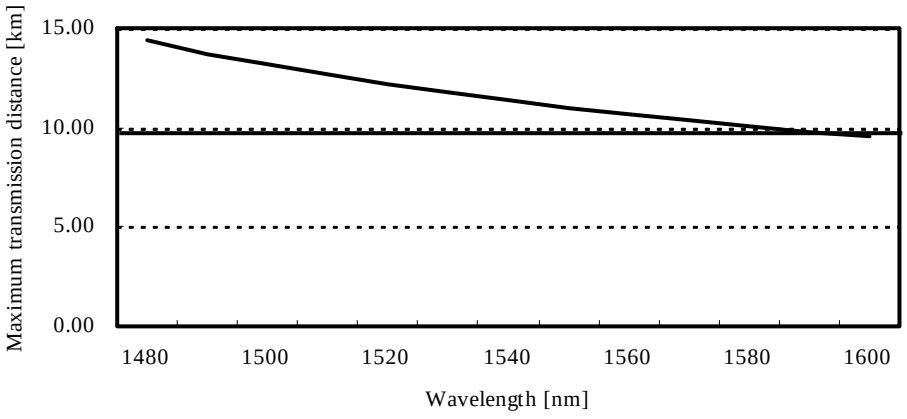


Figure II-1/TS-1000 Transmission distance that can guarantee a power penalty not exceeding 1 dB

(Class S, RMS spectral width = 4.6 nm)

The condition for suppressing the power penalty due to intersymbol interference and mode partition noise to within 1 dB has been described above. Depending on the mode partition phenomenon, the jitter after fiber transmission can increase, resulting in an additional restriction on the transmission distance.

In this Technical Specification, the jitter at the reception side may exceed the optical reception condition specified in IEEE Standard 802.3. So, particularly when a chip set developed for IEEE Standard 802.3 is used, tolerance of the jitter at the reception side needs to be taken into consideration in design.

No detailed study has been made on a jitter increase after fiber transmission due to a mode partition phenomenon. However, a study was made in the case where the central wavelength was 1600 nm, the RMS spectral width was 4.6 nm, and the jitter at the transmission side was 1 ns. The study revealed that the jitter at the reception side after a transmission of 9.6 km was about 2.5 ns, assuming that an increase in jitter is proportional to a fiber dispersion coefficient, spectral width, and transmission distance.

Accordingly, in this Technical Specification, it is recommended that the jitter at the transmission side should be suppressed to 1 ns or less, and that the tolerance of the jitter at the reception side should be made to 2.5 ns or more.

For a duty distortion for considering a tolerance of the jitter at the reception side, a worst possible condition conceivable from the pulse mask at the transmission side and the jitter at the transmission side needs to be considered.

Appendix III Applicable distance of Class Ar

(For TTC Specification TS-1000)

The transmission distance depends on the chromatic dispersion characteristics of the fiber and the light source condition. When a fiber conforming to the ITU-T Recommendation G.652 is used, intersymbol interference and mode partition noise can occur due to the chromatic dispersion characteristics of the fiber and 1.55 μm-region light source condition, resulting in a restriction on the transmission distance.

In accordance with the formula specified in Annex I of TTC Standard JT-G957, the condition for suppressing the power penalty due to intersymbol interference and mode partition noise to within 1 dB is given as follows:

$0.115 \geq 10^{-6} \times$ bit rate (Mbit/s) $\times$ dispersion (ps/nm) $\times$ RMS spectral width

In this Technical Specification, the bit rate is 125 Mbit/s.

In accordance with Section 2.2 "Chromatic dispersion coefficient" of ITU-T Recommendation G.652, the maximum absolute value of a dispersion coefficient in the 1.55 μm region is calculated by the following expressions:

$$\left|D_1(\lambda)\right| = \left|\frac{S_{0\max}}{4}\left[\lambda - \frac{\lambda_{0\min}^4}{\lambda^3}\right]\right| \quad (1)$$

or

$$D_1(\lambda) = [D_{1550} + S_{1550}(\lambda - \lambda_{0\ central})] \quad (2)$$

In this Technical Specification, the wavelength λ that causes the expression above to produce a maximum value is 1600 nm. Moreover, Section 2.2 "Chromatic dispersion coefficient" of ITU-T Recommendation G.652 specifies $S_{0\ max}$ = -0.093 ps/(nm^2·km) and $\lambda_{0\ min}$ = 1300 nm. So, a maximum absolute dispersion coefficient (Expression (1)) of 20.99 ps/(nm·km) is found by calculation. Or, Appendix I of ITU-T Recommendation G.652 specifies D_{1550} = 17 ps/(nm·km), S_{1550} = 0.056 ps/(nm^2·km), and $\lambda_{0\ central}$ = 1550 nm. So, a maximum dispersion coefficient (Expression (2)) of 19.8 ps/(nm·km) is also found.

Therefore, when the RMS spectral width is 3.0 nm, the transmission distance that can guarantee a power penalty not exceeding 1 dB is 14.7 km or less according to Expression (1), or 15.5 km or less according to Expression (2) (See Figure III-1/TS-1000).

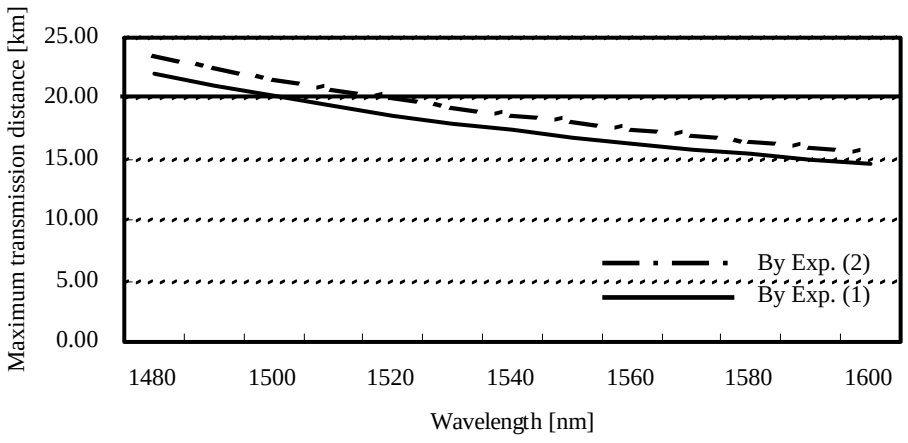


Figure III-1/TS-1000 Transmission distance that can guarantee a power penalty not exceeding 1 dB

(Class Ar, RMS spectral width = 3.0 nm)

The condition for suppressing the power penalty due to intersymbol interference and mode partition noise to within 1 dB has been described above. Depending on the mode partition phenomenon, the jitter after fiber transmission can increase, resulting in an additional restriction on the transmission distance.

In this Technical Specification, the jitter at the reception side may exceed the optical reception condition specified in IEEE Standard 802.3. So, particularly when a chip set developed for IEEE Standard 802.3 is used, tolerance of the jitter at the reception side needs to be taken into consideration in design.

For a duty distortion for considering a tolerance of the jitter at the reception side, a worst possible condition conceivable from the pulse mask at the transmission side and the jitter at the transmission side needs to be considered.