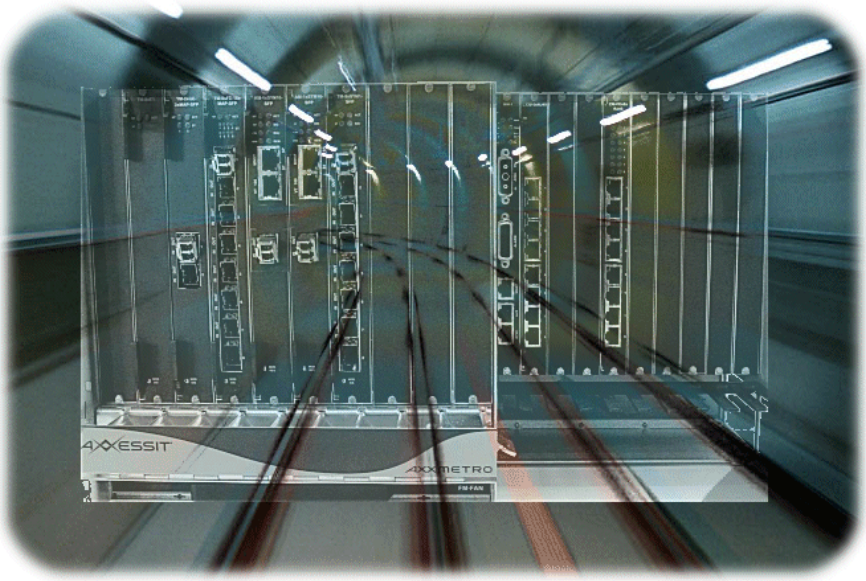
AXXMETRO R1.0

Technical Reference

61019-01AA

Including Service and Remote Modules



AXXESSIT®

Credits

This technical reference could not have been created without the help from the people involved in developing the AXXMETRO.

Dan A. Brunstad
Technical author

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Occurrences of blank pages are intentional to accommodate double-sided printing.

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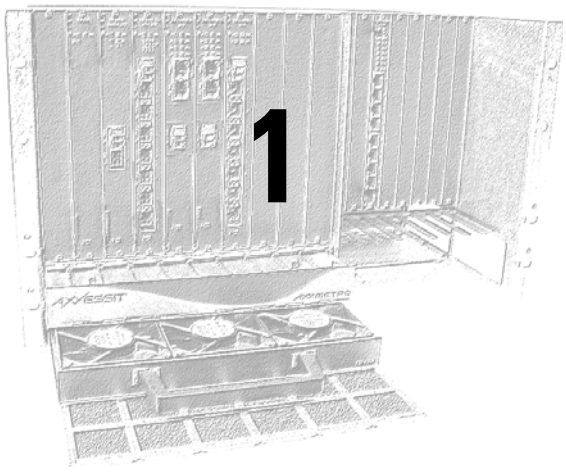


PRODUCT OVERVIEW

1.1 INTRODUCTION

This document describes the applications, features and hardware aspect of the AXXMETRO.

The AXXMETRO is:

- A traffic concentrator for use in fiber-based networks, and it concentrates Ethernet and Time Division Multiplex (TDM)-traffic and is able to interface to both TDM and Ethernet backbone networks.
- A Consolidation Unit (CU) and a Multi Service Provision Platform (MSPP).
- A very flexible network component that can be used in
    - Star networks
    - Ring networks
    - Chained networks
    - Meshed networks
- A Carrier Class product that supports multiple protection schemes that make it suitable for delivering services with an availability of 99.999%.
- A fully working standalone SDH network element (NE).

An element manager (EM) or a network manager (NM), that supervises both the Ethernet and TDM parts of the system, manages the AXXMETRO remotely. Local and remote craft interfaces are also supported with a similar user interface.

The AXXMETRO consists of a 19" or ETSI racks compatible shelf with room for up to 21 plug-in modules of different types comprising:

- 2 aggregate modules
- 8 tributary modules
- 8 connector modules
- 2 miscellaneous modules
- 1 fan module.

In addition there is room for a cable management area that handles both the optical fibers and the copper cables. The front view is shown in the figure below.

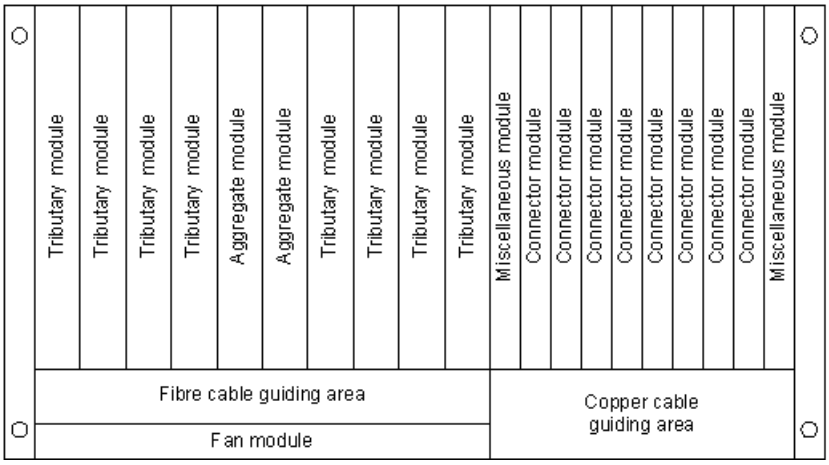


Figure 1-1. Front View

The AXXMETRO supports a number of modules with various physical interfaces. The modules can be divided into groups indicated by the two first letters in their names.

Type	Name	Description
AM	Aggregate Module	TDM matrix, Ethernet Crossbar, System controller and SDH interfaces.
TM	Tributary Module	SDH, Ethernet and PDH interfaces
MM	Miscellaneous Module	Additional physical interfaces for the aggregate modules - power, management, sync, aux. alarm.
CM	Connector Module	Physical interface for the PDH, SDH and fast Ethernet copper interfaces
FM	Fan Module	Ventilation fan

Table 1.1. Module types

Table 1.2. below shows the slots where the different modules can be placed, indicated by the ✔ symbol.

Slot no.	AM	L1Eth	L2Eth	E1	E1 Prot	E3	E3 Prot	SDH	SDH Prot	MM	CM E1	CM E3/SDH	CM E3/SDH Prot	CM FE L1	CM FE L2	FM
1		✔		✔		✔		✔								
2		✔			✔	✔	✔	✔	✔							
3		✔	✔	✔		✔		✔								
4		✔	✔		✔	✔	✔	✔	✔							
5	✔															
6	✔															
7		✔		✔		✔		✔								
8		✔			✔	✔	✔	✔	✔							
9		✔	✔	✔		✔		✔								
10		✔	✔		✔	✔	✔	✔	✔							

Slot no.	AM	L1Eth	L2Eth	E1	E1 Prot	E3	E3 Prot	SDH	SDH Prot	MM	CM E1	CM E3/SDH	CM E3/SDH Prot	CM FE L1	CM FE L2	FM
11										✔						
12											✔	✔	✔	✔		
13												✔		✔		
14											✔	✔	✔	✔	✔	
15												✔		✔	✔	
16											✔	✔	✔	✔		
17												✔		✔		
18											✔	✔	✔	✔	✔	
19												✔		✔	✔	
20										✔						
21																✔

Table 1.2. Slot limitations in AXXMETRO shelf

The AXXMETRO must have at least one AM and one MM to work properly. The AM can be placed in slot 5 or slot 6.

- AM in slot 5 -> MM in slot 11
- AM in slot 6 -> MM in slot 20

Note that if 1:1 equipment protection is used slots 1, 3, 7 and 9 are used as working slots and slots 2, 4, 8 and 10 are used as protection slots for the TM. The protection slots can be used for other type of modules if 1:1 equipment protection is not used.

The same CM for E1 interfaces is used without and with equipment protection.

Two different CMs are used for the E3, T3 and STM-1e interfaces. The protection CM occupies two slots.

The Ethernet TM can be mounted in all tributary slots. Note that L2 features are only supported in four of the slots (3, 4, 9 and 10). L1 features are supported in all slots.

The MMs are connected to both AM slots. The CMs are directly connected to the respective TM slots as shown below:

- CM in slot 12 is connected to TM in slot 1
- CM in slot 13 is connected to TM in slot 2
- CM in slot 14 is connected to TM in slot 3
- CM in slot 15 is connected to TM in slot 4
- CM in slot 16 is connected to TM in slot 7
- CM in slot 17 is connected to TM in slot 8
- CM in slot 18 is connected to TM in slot 9
- CM in slot 19 is connected to TM in slot 10

1.2 AXXMETRO USED AS AN ADM

The main application for AXXMETRO is to use it as an Add/Drop Multiplexer (ADM). A number of sites are connected with a ring network topology. The AXXMETRO is used to drop traffic in the different sites. This is shown in the figure below.

The AXXMETRO is typically deployed in the operator's point of presence, but it may also be deployed on customer sites.

The AXXMETRO connects both local customers in the deployment building and customers in remote sites. A CPE (e.g. AXXCONNECT or AXXEDGE) is used to connect the remote customers to the AXXMETRO.

The AXXMETRO provides a number of services at the sites (e.g. TDM leased lines, ISDN PRA, Synchronisation, Ethernet leased lines and Internet access).

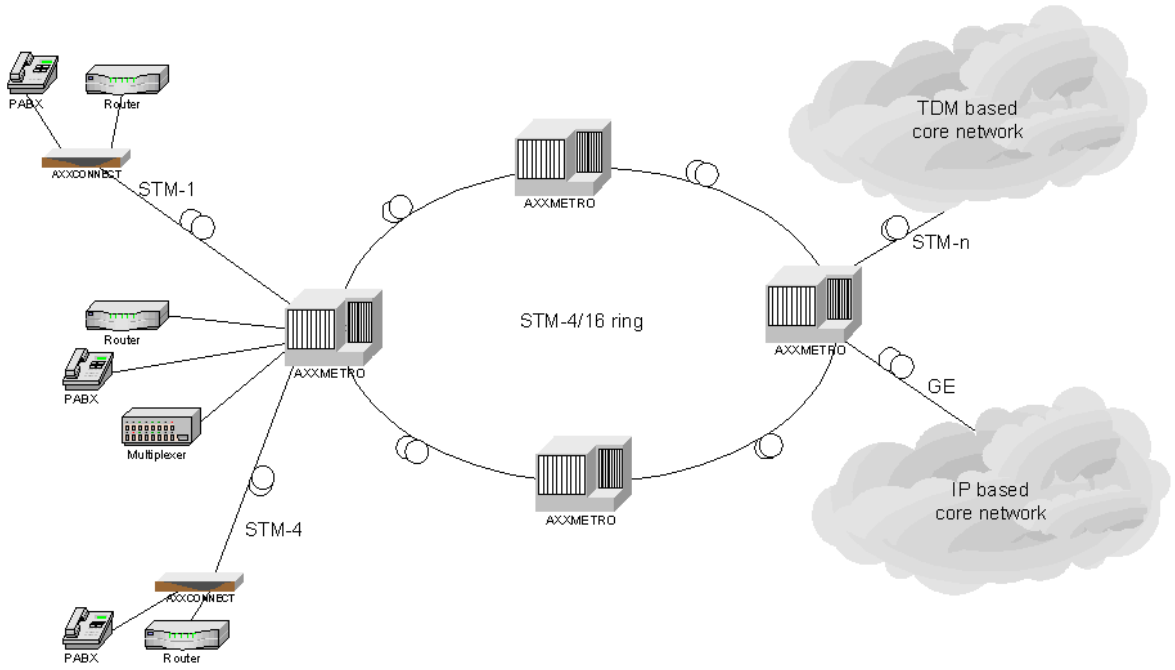


Figure 1-2. AXXMETRO as an ADM

The AXXMETRO also supports multiple rings as shown in the figure below. AXXMETRO supports 2F ring structures.

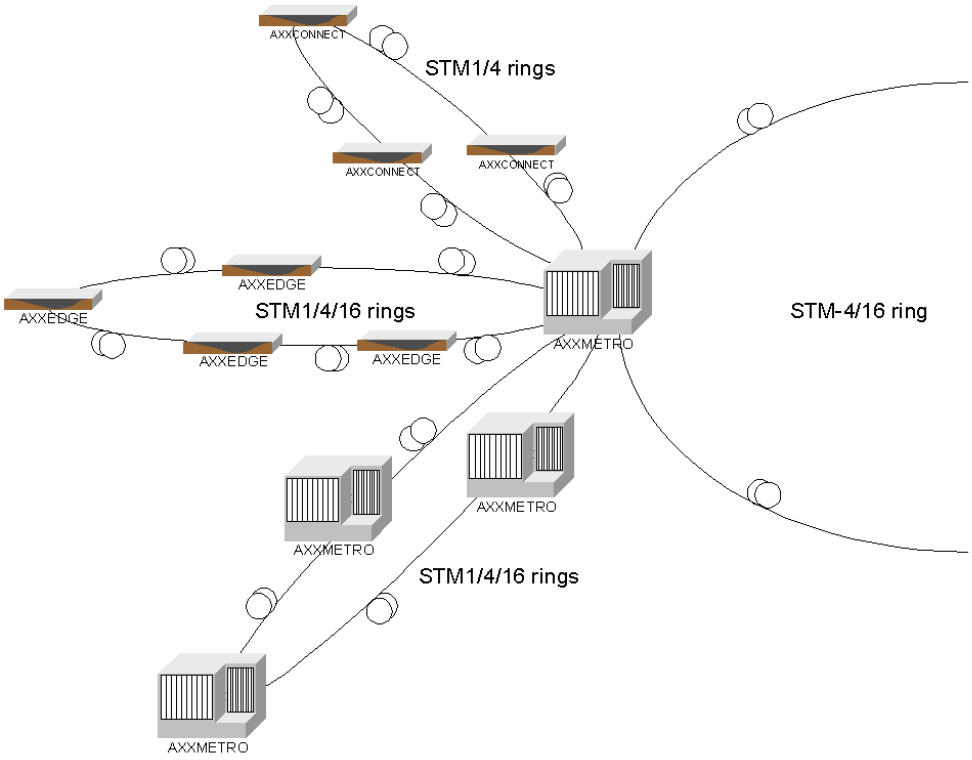


Figure 1-3. Multiple ring setup

1.3 AXXMETRO USED AS A CONSOLIDATION UNIT

The AXXMETRO can also be used as a consolidation unit (CU) in the operator's point of presence (POP) as shown in the figure below.

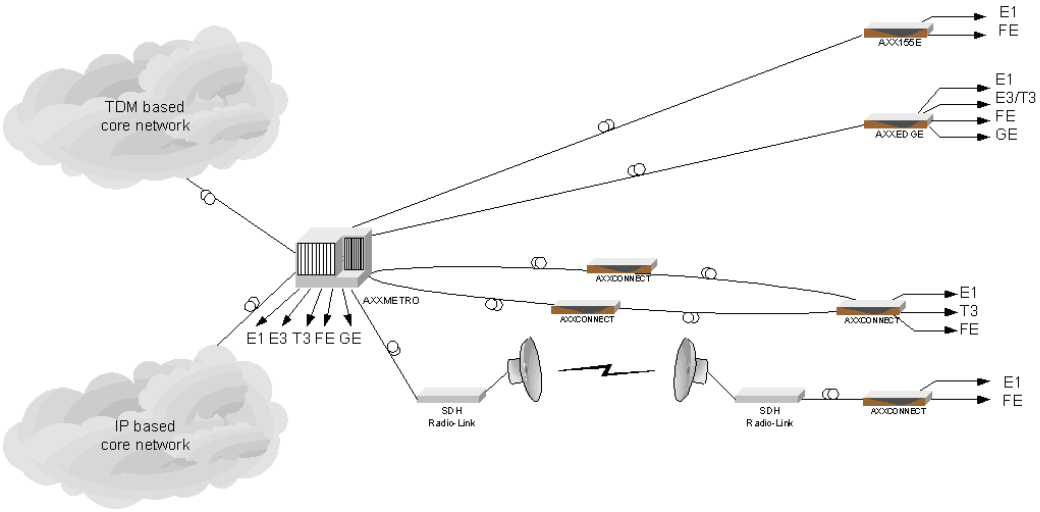


Figure 1-4. AXXMETRO as a consolidation unit

The AXXMETRO concentrates local traffic in the POP with traffic from the end customer sites before sending it to the core network.

The AXXMETRO can be connected to TDM based and/or packet based core networks.

1.4 AXXMETRO USED WITH AN AXXEDGE DROP SHELF

There may not be enough modules and interfaces in the AXXMETRO in high-density CU applications. The AXXEDGE may be used as a drop shelf for the AXXMETRO to increase the number of interfaces or the capacity of the system as shown in the figure below.

The AXXMETRO and AXXEDGE are connected through the fiber or copper interfaces.

Note that the AXXEDGE is still treated as a separate network element and have its own system controller.

The most typical application is to drop a large number of E1 interfaces in one site. The AXXMETRO can drop up to 252 E1 in a rack. Two additional AXXEDGE would make it possible to drop up to 630 E1s. Four AXXEDGEs makes it possible to drop 1008 E1s. The rack space needed for this is only 10 rack units (RU) or 445 mm. Note that this does not include the patch panels.

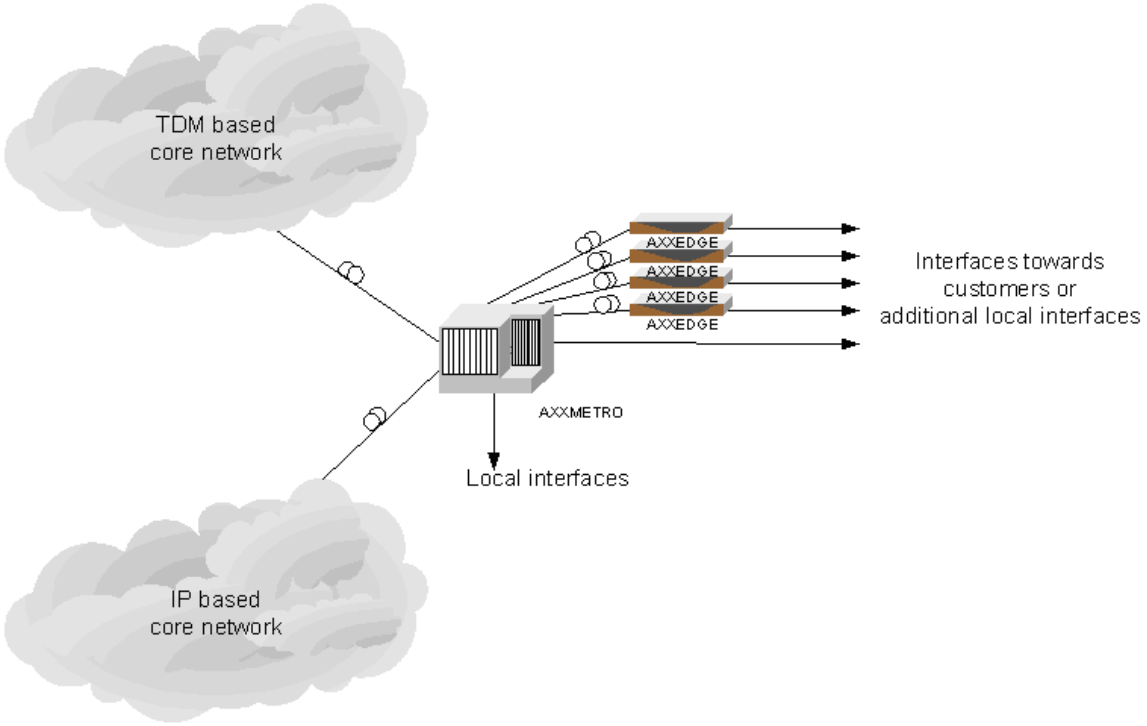
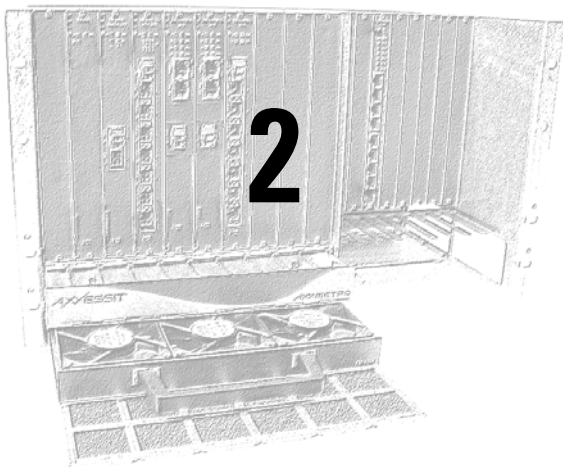


Figure 1-5. AXXMETRO with AXXEDGE drop shelves

FEATURES



2.1 SDH FEATURES

2.1.1 Multiplexing structure

The AXXMETRO complies with the basic multiplexing principles outlined in Clause 6 in ITU-T G.707 and ETSI EN 300147 clause 4. The figure below illustrates a subset of the possible multiplexing structures:

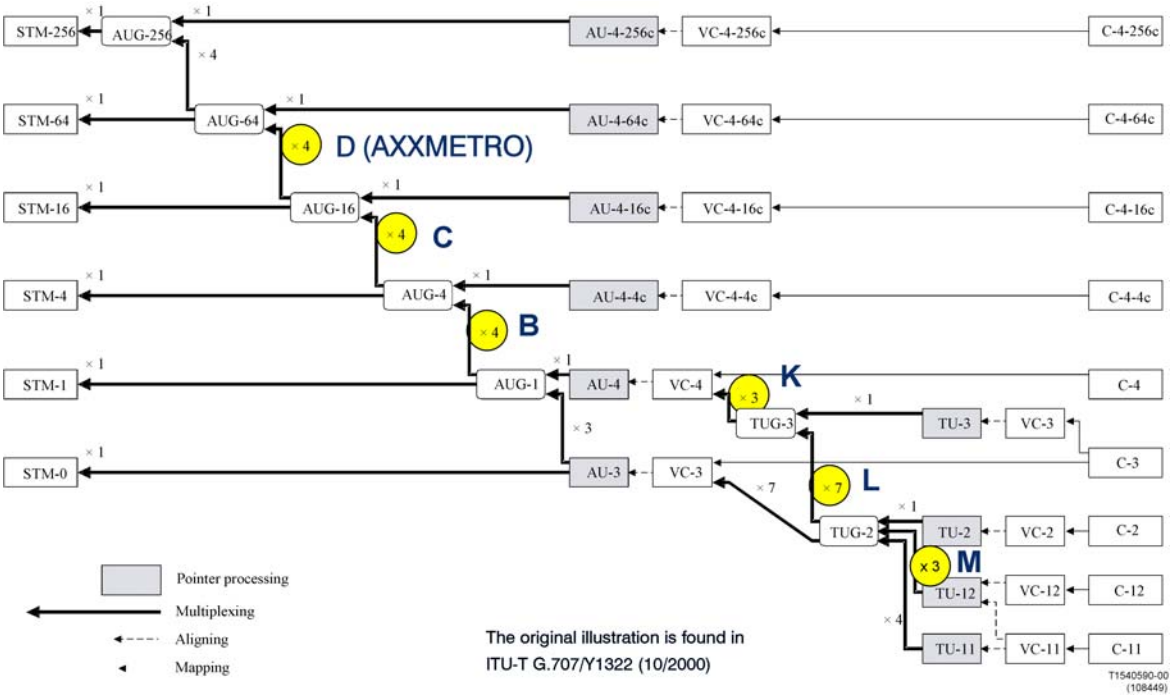


Figure 2-1. Supported multiplexing structures

The AXXMETRO complies with the multiplexing methods outlined in clause 7 in ITU-T G.707 and ETSI EN 300 147 clause 5 for the supported multiplexing structures.

2.1.2 Mapping of tributaries into VC-n

Asynchronous mapping of 44 736 kbps

The AXXMETRO supports asynchronous mapping of 44 736 Kbps signal into a VC-3 container as shown in Figure 2-2. The mapping is in accordance to ITU-T G.707 clause 10.1.2.1 and ETSI EN 300 147 Clause 8.

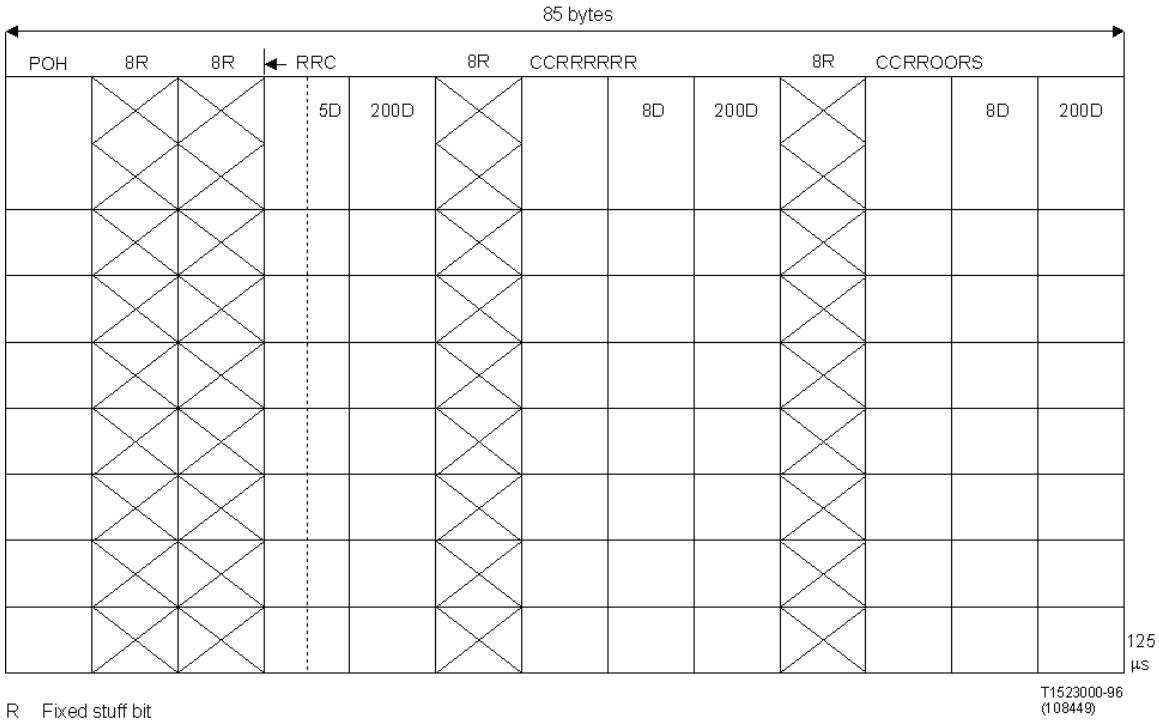


Figure 2-2. Asynchronous mapping of 44 736 kbps tributary into VC-3

Asynchronous mapping of 34 368 kbps

The AXXMETRO supports asynchronous mapping of 34 368 kbps signal into a VC-3 container as shown in Figure 2-3. The mapping is in accordance to ITU-T G.707 clause 10.1.2.2 and ETSI EN 300 147 Clause 8.

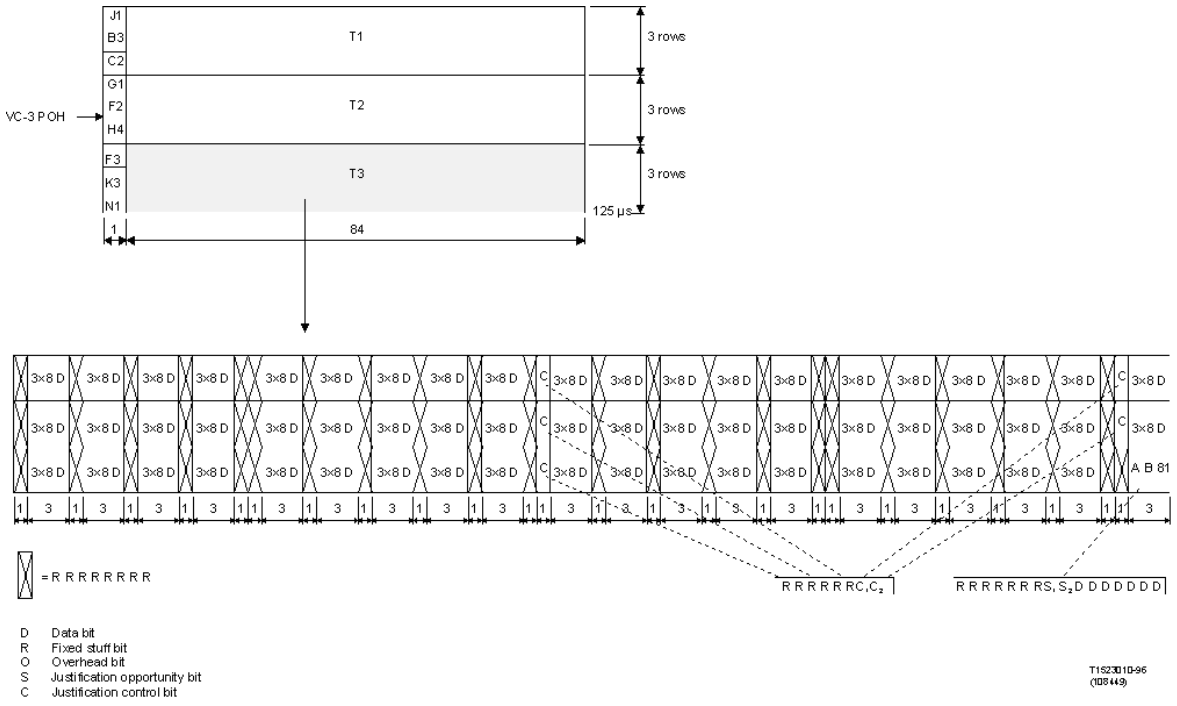


Figure 2-3. Asynchronous mapping of 34 368 kbps tributary into VC-3

Asynchronous mapping of 2048kbps

The AXXMETRO supports asynchronous mapping of 2048kbps signal into a VC-12 container as shown in Figure 2-4. The mapping is in accordance to ITU-T G.707 clause 10.1.4.1 and ETSI EN 300 147 Clause 8.

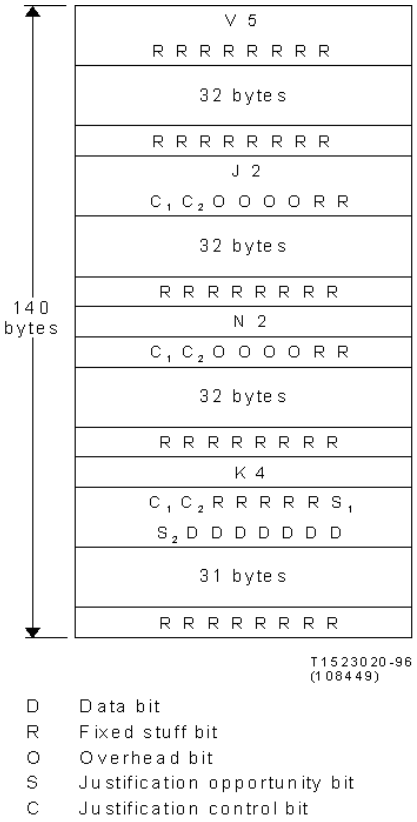


Figure 2-4. Asynchronous mapping 2048 kbps tributary into VC-12

Mapping of GFP frames

The AXXMETRO supports the generic framing procedure (GFP) to encapsulate variable length payload of various client signals for subsequent transport over SDH networks as defined in ITU-T G.707. The AXXMETRO supports mapping of a GFP frame stream into a Container-n (n=12,3,4 or 12/3/4-Xv) as shown in Figure 2-5. The mapping is in accordance to ITU-T G.707 clause 10.6.

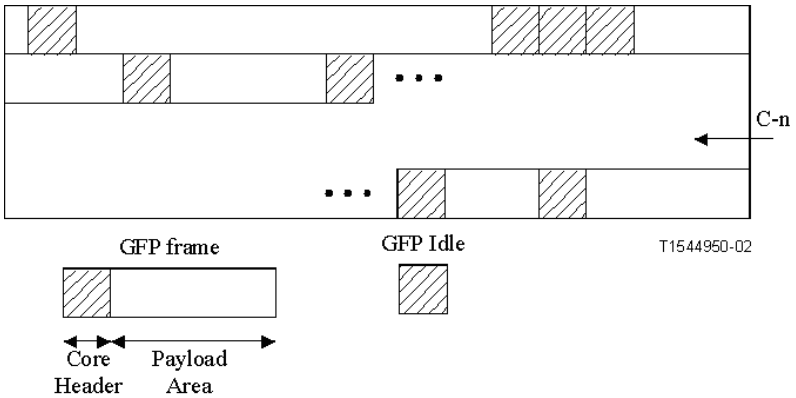


Figure 2-5. Mapping of GFP frames into C-n

AXXESSIT proprietary mapping of HDLC frames

The AXXMETRO provides a proprietary mapping scheme for mapping of HDLC encapsulated Ethernet frames traffic into VC-12 containers. The proprietary mapping scheme used to map the data into a VC-12 container is described in Figure 2-6.

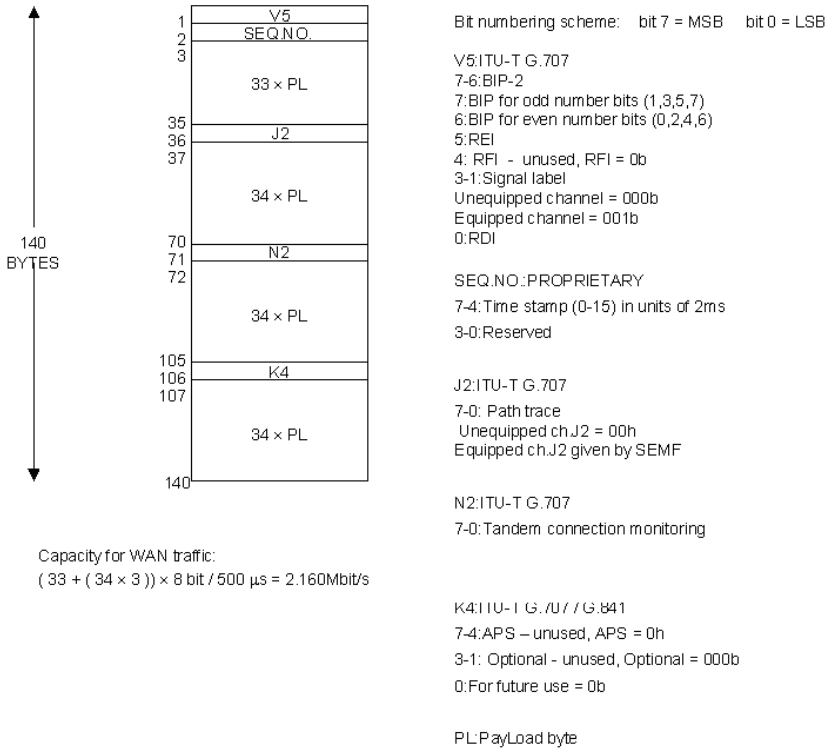


Figure 2-6. AXXESSIT proprietary mapping of HDLC frames

The mapping scheme is compliant to the mapping scheme offered in other AXXESSIT network elements.

SDH layer functions

STM-N Physical layer

The AXXMETRO offers the following physical interfaces:

- Optical STM-1 interfaces, S1.1, L1.1, L1.2
- Optical STM-4 interfaces, S4.1, L4.1, L4.2
- Optical STM-16 interfaces, S16.1, L16.1, L16.2
- CWDM for STM-1, STM-4 and STM16 interfaces
- Electrical STM-1 interface

The AXXMETRO implements the supported Physical layer functions in accordance to ITU-T G.783 clause 9.

READ MORE: **Detailed specification of each physical interface in Chapter 7.**

STM-N Regenerator and Multiplex Section layer

The AXXMETRO implements the STM-N (n=1,4 and16) Regenerator and Multiplex Section layer functions in accordance to ITU-T G.783 clause 10 and 11.

SOH implementation

The AXXMETRO complies with the SOH implementation methods outlined in clause 9 in ITU-T G.707 and ETSI EN 300 147 clause 7. The assignment of the STM-1 SOH is outlined in Figure 2-7.

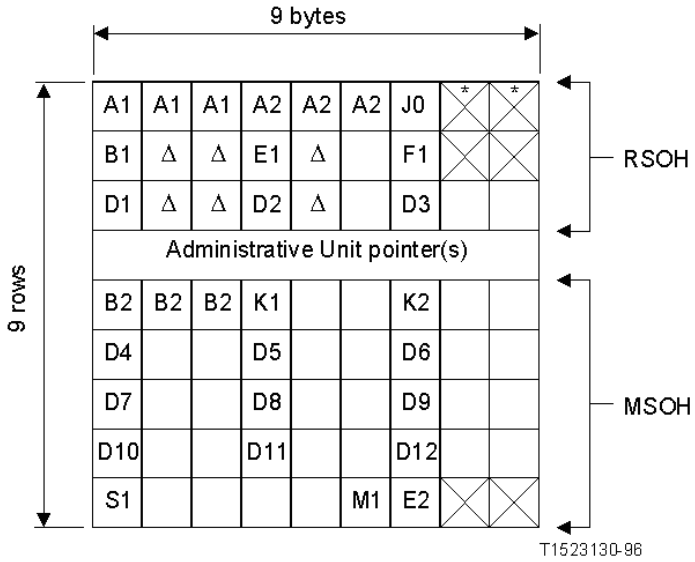


Figure 2-7. STM-1 SOH

The AXXMETRO supports all the SOH bytes as described in ITU-T G.707 Clause 9.2, with the following exceptions:

- Forward Error Correction bytes P1, Q1 are not supported for STM-16 connections
- Z0 bytes are unused bytes and they are not supported for STM-4 and STM-16 connections

VC-n/m Path layer

The AXXMETRO offers the support of the following payloads:

- VC-4
- VC-4-Xv
- VC-3
- VC-3-Xv
- VC-12
- VC-12-Xv

READ MORE: The support of the VC-12/3/4-Xv virtual concatenation is described on page 2-9

The AXXMETRO implements the supported Path layer functions in accordance to ITU-T G.783 clause 12 for VC-n, where n=4-Xv, 4, 3-Xv or 3.

The AXXMETRO implements the supported Path layer functions in accordance to ITU-T G.783 clause 13 for VC-m, where m=12-Xv or 12.

VC-4-Xc/VC-4/VC-3 POH implementation

The AXXMETRO complies with the POH implementation methods outlined in clause 9 in ITU-T G.707 and ETSI EN 300 147 clause 7. The assignment of the VC-4 POH is outlined in Figure 2-8.

The AXXMETRO supports all the VC-4-Xc/VC-4/VC-3 POH bytes as described in ITU-T G.707 Clause 9.3.1, with the following exceptions:

- G1 bit 6 and 7 Enhanced RDI, Clause 9.3.1.4 are not supported
- Path user channels F2 and F3, Clause 9.3.1.5 are not supported
- K3 byte, Clause 9.3.1.7, 9.3.1.9-10 is not supported
- Network operator byte N1, Clause 9.3.1.8 is not supported

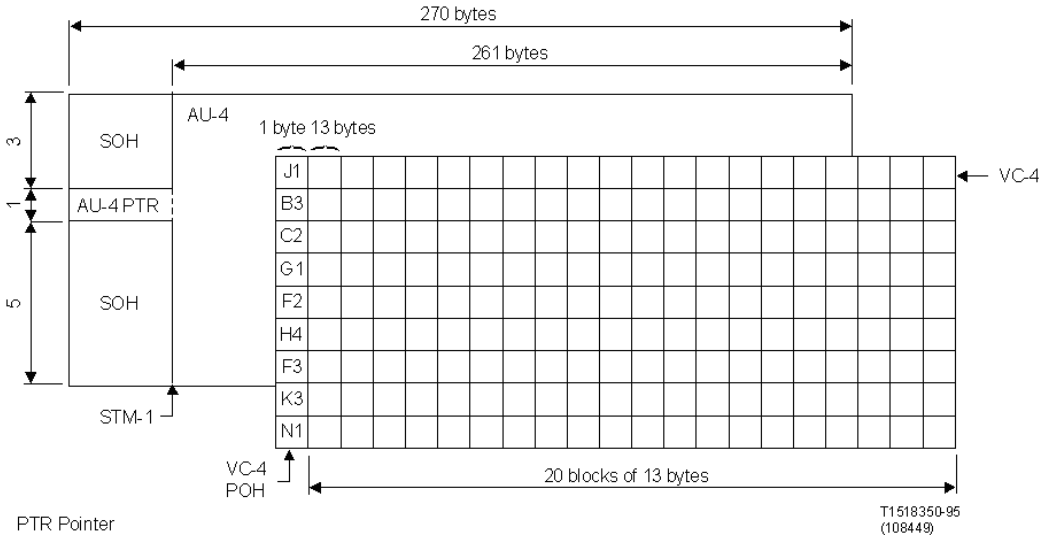
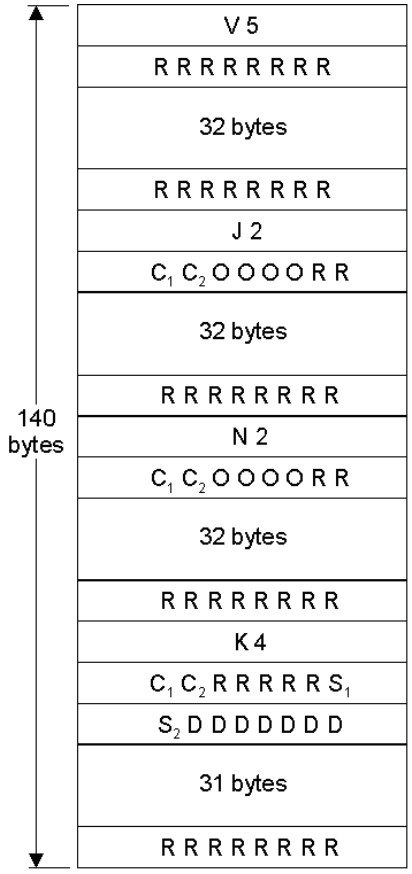


Figure 2-8. VC-4 POH

VC-12 POH implementation

The AXXMETRO complies with the POH implementation methods outlined in clause 9 in ITU-T G.707 and ETSI EN 300 147 clause 7. The assignment of the VC-12 POH is outlined in Figure 2-9.



D Data bit
R Fixed stuff bit
O Overhead bit
S Justification opportunity bit
C Justification control bit

Figure 2-9. VC-12 POH

The AXXMETRO supports all the VC-12 POH bytes as described in ITU-T G.707 Clause 9.3.2, with the following exceptions:

- Network operator byte N2, Clause 9.3.2.3 is not supported
- K4 byte (b3-b8), clause 9.3.2.6-8 is not supported

Concatenation schemes

Contiguous concatenation

AXXMETRO supports standard contiguous concatenation at VC-4-4c and VC-4-16c level. The AXXMETRO implements the supported VC-4-4c and VC-4-16c in accordance to ITU-T G.707 clause 11.1 and ETSI EN 300 147 Clause 9.

The support for the standard concatenation scheme includes the following features:

- Support of cross connection
- Support of SNC protection
- IPPM support

In addition to the standard concatenation the AXXMETRO supports two proprietary concatenation schemes.

- VC-4-2c
- VC-4-8c

The support for the proprietary concatenation scheme includes the following features:

- Support of cross connection
- Support of SNC protection
- IPPM support

The following modules support contiguous concatenation:

- All optical STM-16 modules support VC-4-2c, VC-4-4c, VC-4-8c and VC-4-16c
- All optical STM-4 modules support VC-4-2c and VC-4-4c

Virtual concatenation

AXXMETRO supports virtual concatenation, the following VC-n-Xv are supported:

- VC-12-Xv
- VC-3-Xv
- VC-4-Xv

The AXXMETRO implements the supported VC-4-Xv and VC-3-Xv functionality in accordance to ITU-T G.707 clause 11.2 and ETSI EN 300 147 Clause 9.

The AXXMETRO implements the supported VC-12-Xv functionality in accordance to ITU-T G.707 clause 11.4 and ETSI EN 300 147 Clause 9.

Virtual concatenation is supported in conjunction with EOS mapping and is module dependent. EOS mapping is described on page 2-29.

Cross-connect support

General information

The AXXMETRO implements a two stage cross connect, consisting of a higher order and a lower order part. The higher order part is non-blocking and equal to 256x256 STM-1 equivalents and offer connections for the following objects:

- VC-4
- VC-4-2c
- VC-4-4c
- VC-4-8c
- VC-4-16c

NOTE! **The matrix size includes the connection to the lower order matrix. The size is 160x160 STM-1 equivalents if the lower order matrix is not included.**

The lower order cross connect is equal to 96x96 STM-1 equivalents and offer connections for the following objects:

- VC-3
- VC-12

The AXXMETRO cross connect matrix supports different cross connect basic types, which are used to build more complex cross connects. The basic cross connect types are:

- Basic cross connect types:
    - Uni-directional, un-protected point-to-point
    - Bi-directional, un-protected point-to-point
    - Uni-directional, protected point-to-point of type "add"
    - Uni-directional, protected point-to-point of type "drop"
    - Bi-directional, protected point-to-point
    - Drop and Continue
- Broadcast Cross Connection
    - Local broadcast, unprotected
    - Continue broadcast, unprotected
- Ring-to-ring Cross Connections
    - With double add and drop

Basic cross connect Types

The cross connect term is used to describe a connection internally across the termination points of a Cross Connect matrix.

The cross connects are performed in any AU or TU layer of the SDH cross connect. All termination points must be located in the same layer.

A cross connect contains up to three termination points, uni- or bi-directional: A (source/transmit), B (sink/receive) and P (protecting). Depending on the type of P-t-P, the XC matrix allows various internal connections between the termination points.

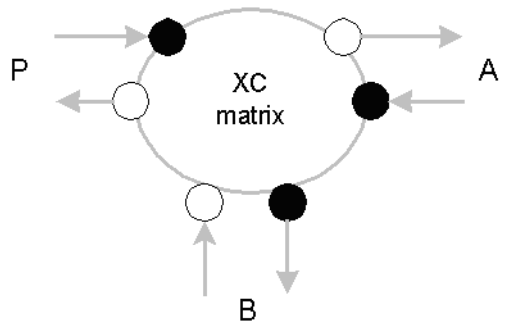


Figure 2-10. Generic basic cross connect

Uni-directional traffic flow through the matrix is fixed to one path between the "A" termination point to the "B" termination point as shown in the figure below.

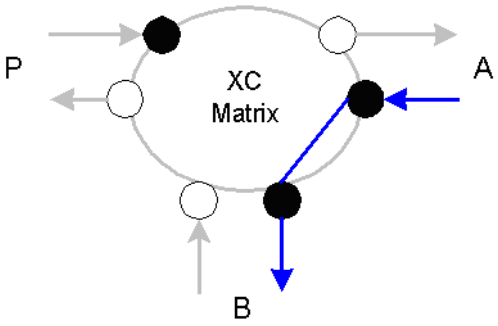


Figure 2-11. Uni-directional PtP cross connect

Bi-directional traffic flows through the matrix in both direction, between A and B during normal operation as shown in the figure below.

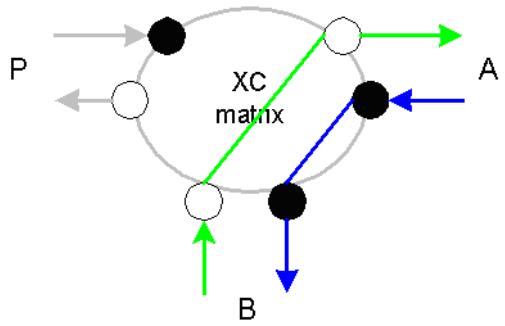


Figure 2-12. Bi-directional PtP cross connect

Circuit protection is established by splitting the circuit in two paths. This uni-directional protected PtP cross connect of type “add” is used to split the traffic.

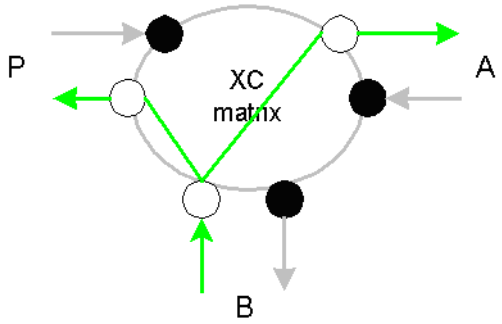


Figure 2-13. Uni-directional PtP cross connect with protection (add)

This uni-directional protected PtP cross connect of type “drop” is used to assemble circuits that was split with a previous "add" cross connect.

Traffic through B is routed from either the "A" termination point or "P" termination point.

The criteria for switching A or P to B is the measured quality of the signals received from A and P (unless forced by the TMN operator).

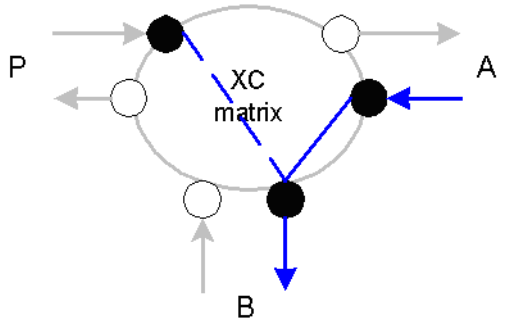


Figure 2-14. Uni-directional PtP cross connect with protection (drop)

The bi-directional connection from A to B is protected. In this configuration the B termination point is protected.

The criteria for switching A or P to B is the measured quality of the signals received from A and P (unless forced by the TMN operator).

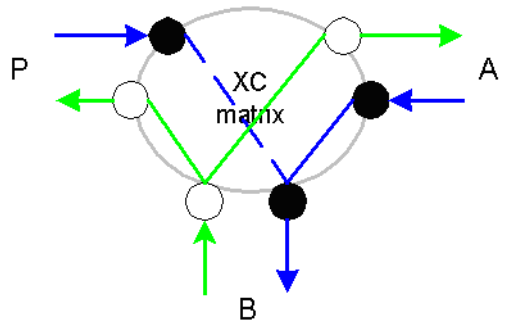


Figure 2-15. Bi-directional PtP cross connect with protection

This cross connect is used to connect traffic between two SDH rings. Current version of the AXXMETRO supports bi-directional Add and Drop only

A is set up towards the source, P is the alternate route within the same ring, and B is towards the other ring.

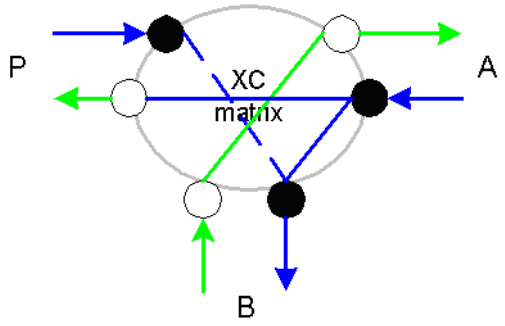


Figure 2-16. Point-to-point drop and Continue

Broadcast cross connect

A broadcast cross connect is a uni-directional point-to-multipoint cross connect, built from several broadcast legs.

A broadcast cross connect can be viewed as a complex attribute, consisting of several basic PtP cross connections that shares the same A termination point.

One broadcast input termination point (A) with several drop-off legs to termination points B<n>.

"A" TP is mandatory and "B" TPs can be added or deleted. At least one "B" TP is mandatory.

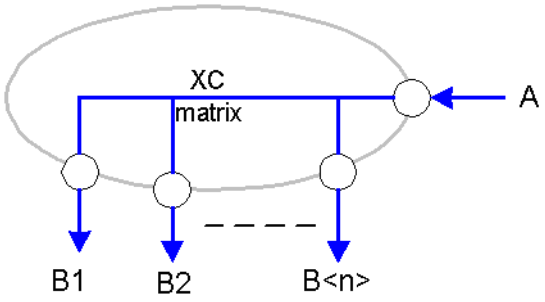


Figure 2-17. Unprotected local broadcast

One pass-through broadcast input/output termination point "A" and "C" with several drop-off legs to termination points "B<n>".

"A" and "C" TP's are mandatory, "B" TP's can be added or deleted.

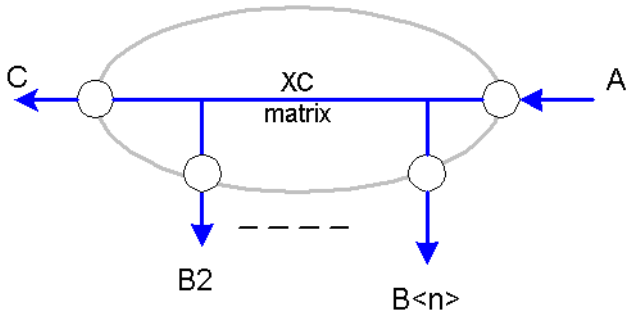


Figure 2-18. Continue broadcast, un-protected

Complex cross connect types

The AXXMETRO cross connect is divided into two sub-units, a high layer cross connect and a lower layer cross connects. This corresponds to the ITU-T sub-division of the SDH frame payload area into Administrative Units (AUs) and Tributary Units (TUs), where the higher order XC cross connects the AUs, and the lower order XC cross connects the TUs.

Protected ring interconnection with protection where two rings enter the network element includes two SNCP instances.

This scheme assumes that fully protected ring-to-ring interconnection is implemented by one network element.

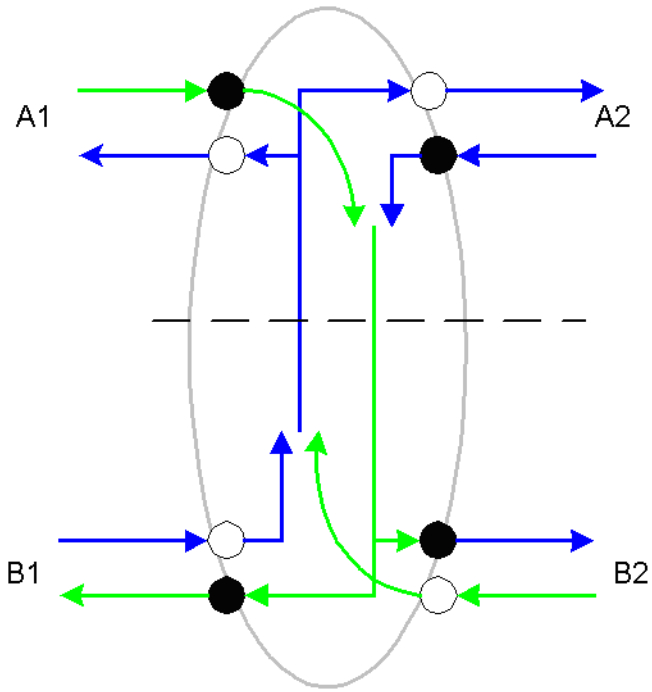


Figure 2-19. Double Add & drop

VC-4 tunneling

AXXMETRO supports creation of VC-4 "tunnel" cross-connections towards PDH modules (E1 or E3). This cross-connection is a standard AU-4/VC-4 cross-connection created towards a "Port Group" on the PDH module. A "Port Group" supports 3xVC-3 or 63xVC-12. Hence there is one port group on an 8xE1 or 63xE1 module, and two port groups on a 6xE3/T3 module.

Within the VC-4 tunnel, there is a fixed relation between the VC-3/12's (K.L.M) and the PDH ports. I.e. E1 port 1 is connected to the VC-12 with K.L.M = 1.1.1, and E1 port 63 is connected to the VC-12 with K.L.M = 3.7.3. For E3/T3 ports, port 1 is connected to the VC-3 with K = 1, while port 3 is connected to the VC-3 with K = 3.

The VC-4 tunnel cross-connection is implemented via the high-order matrix only, and thus uses no resources in the low-order matrix. The VC-4 Tunnel cross-connection is always bi-directional.

Protection

AXXMETRO offers a wide range of protection schemes, the first release supports the following:

- 1:1 Equipment protection
- 1+1 MSP protection
- SNC protection

1:1 Equipment protection

AXXMETRO offers 1:1 equipment protection. The protection switch algorithm operates as fast as possible and guarantees a switching time of less than 50ms. The AXXMETRO offers 1:1 protection groups for the following types of modules:

- n x E1 tributary modules
- n x E3/T3 tributary modules
- STM-1 electrical tributary modules

Only non-revertive switching is supported. (no automatic switchback after a protection switchover)

The working modules are placed in the odd numbered slots and the protection modules are placed in the even numbered slots. The protection groups are only valid for 1:1 protection, the protection structure is outlined in Table 2.1.

Working module	Protecting module
1	2
3	4
7	8
9	10

Table 2.1. Protection groups

A protection may occur based on a module failure or an activated command from the operator. In case of a switch request based on a module fail, the switching time is less than 50ms. The switching criteria and the priority levels are outlined in Table 2.2.

Switch request/state:	Order of priority:
Clear	1
Forced switch	2
Module fail	3
Manual switch	4

Table 2.2. Switch request and priority

The different switch requests and switch states have the following implementation:

Clear:

This command clears all the externally initiated commands listed in Table 5.

Forced switch:

This command forces a protection switch regardless of status of the modules involved.

Module fail:

Module fail is a module state that indicates that the module is not able to carry traffic. Such a state under normal conditions causes a protection switch unless one of the following cases is true:

- Forced switch command is active
- Protection module is in module fail state

Manual switch:

A manual switch command forces a protection switch unless the protection module is in a module fail state.

1+1 linear MSP

AXXMETRO offers 1+1 linear Multiplex Section Protection (MSP) on all STM-N interfaces.

The following rules apply for the 1+1 MSP protection:

- Protection can only be enabled between two ports of the same STM-N type
- Protection can be enabled between two ports on the same module
- Protection can be enabled between two ports located on different modules
- Protection can not be enabled between a port on a tributary module and a port on a aggregate module

The 1+1 MSP functionality is in accordance with ITU-T G.841, clause 7.1. The following parameters are configurable on an MSP object:

- Enabled/disabled
- Mode, unidirectional or bi-directional
- Operation Type, revertive or non-revertive
- WTR time (Wait to restore time), configurable from 0-15minutes, default 5 minutes

The protocol used for K1 and K2 (b1-b5) is defined in ITU-T G.841, clause 7.1.4.5.1. The protocol used is 1+1 bi-directional switching compatible with 1:n bi-directional switching.

SNC Protection

AXXMETRO supports two types of SNC protection:
SNC/I (Sub Network Connection protection with Inherent monitoring) and
SNC/N (Sub Network Connection protection with non-intrusive monitoring).

SNC Protection (SNCP) is supported for the following layers:

- VC-12
- VC-3
- VC-4
- VC-4-2c
- VC-4-4c
- VC-4-8c
- VC-4-16c

The SNCP functionality is in accordance with ITU-T G.841 Clause 8. The following parameters are configurable on an SNCP object:

- Enabled/disabled
- Operation Type, revertive or non-revertive
- Hold-off time, configurable from 0-10s in 100ms steps, default 0s
- WTR time (Wait to restore time), configurable from 0-15minutes, default 5 minutes

The Application architecture supported is 1+1 unidirectional switching according to ITU-T G.841 clause 8.3.2. The switch initiation criteria are implemented as described in ITU-T G.841 clause 8.4.

The protection algorithm is implemented according to ITU-T G.841 clause 8.6.

Performance monitoring

In the subsequent chapters the following definition is used, according to G.826:

Term	Abbr.	Description
Errored Second	ES	A one second period with one or more errored blocks or at least one defect.
Severely Errored Second	SES	A one second period which contains >= X% errored blocks or at least one defect (where X is defined in the relevant recommendations e.g. G.826, G.828 and G.829)
Background Block Error	BBE	An errored block not occurring as a part of an SES
Unavailable Seconds	UAS	A period of unavailable time begins at the onset of ten consecutive SES events. These ten seconds are considered to be part of unavailable time. A new period of available time begins at the onset of 10 consecutive non-SES events. These ten seconds are considered to be part of available time. UAS is the number of second of unavailable time.

Table 2.3. Performance monitoring abbreviations

Regenerator and multiplex section performance monitoring

AXXMETRO offers full performance monitoring on regenerator and multiplex sections according to G.829.

The following parameters are calculated:

- ES
- SES
- BBE
- UAS

For the regenerator section near end data are presented, for the multiplex section both near end and far end data are presented.

The available time periods are:

- 15 minutes
- 24 hours

The system presents current data and historical data, the number of historical time periods are:

- 16x15 minute
- 1x24 hours

AXXMETRO calculates excessive error and degrade signal defects assuming Poisson distribution of errors, according to ITU-T G.826.

The excessive error defect (dEXC) is detected if the equivalent BER exceeds a pre-set threshold of 10E-5, and cleared if the equivalent BER is better than 10E-6, according to ITU-T G.806.

The degraded signal defect (dDEG) is detected if the equivalent BER exceeds a pre-set threshold of 10E-X, where X=6, 7, 8 or 9. The dDEG is cleared if the equivalent BER is better than 10E-(X+1), according to ITU-T G.806. The thresholds are individual configurable for the regenerator and multiplex section, from 10E-6 to 10E-9.

Path performance monitoring

AXXMETRO offers full performance monitoring on the SDH path level according to G.828.

The following objects are supported:

- VC-12
- VC-3
- VC-4
- VC-4-4c

The following parameters are calculated:

- ES
- SES
- BBE
- UAS

Both near end and far end data are presented and the available time periods are:

- 15 minutes
- 24 hours

The system presents current data and historical data, the number of historical time periods are:

- 16x15 minute
- 1x24 hours

AXXMETRO calculates excessive error and degrade signal defects assuming Poisson distribution of errors, according to ITU-T G.826.

The excessive error defect (dEXC) is detected if the equivalent BER exceeds a pre-set threshold of 10E-5, and cleared if the equivalent BER is better than 10E-6, according to ITU-T G.806.

The degraded signal defect (dDEG) is detected if the equivalent BER exceeds a pre-set threshold of 10E-X, where X=6, 7, 8 or 9. The dDEG is cleared if the equivalent BER is better than 10E-(X+1), according to ITU-T G.806. The thresholds are individual configurable for the different objects, from 10E-6 to 10E-9.

Intermediate path performance monitoring

AXXMETRO supports IPPM (Intermediate Path Performance monitoring) functions on the following objects:

- VC-12
- VC-3
- VC-4
- VC-4-2c
- VC-4-4c
- VC-4-8c
- VC-4-16c

The functionality is used to monitor relayed cross connections in the system. The functionality is especially useful for debugging of errored paths to determine which section is causing the problem. The functionality is also used to monitor paths crossing operator borders.

The functionality is supported by use of the non-intrusive monitor points used by the SNCP process. A probe is placed on the selected object and the performance monitoring is then automatically turned on.

The following parameters are calculated:

- ES
- SES
- BBE
- UAS

Both near end and far end data are presented and the available time periods are:

- 15 minutes
- 24 hours

The system presents current data and historical data and the number of historical time periods are:

- 16x15 min
- 1x24 hrs.

AXXMETRO calculates excessive error and degrade signal defects assuming Poisson distribution of errors, according to ITU-T G.826.

The excessive error defect (dEXC) is detected if the equivalent BER exceeds a pre-set threshold of 10E-5, and cleared if the equivalent BER is better than 10E-6, according to ITU-T G.806.

The degraded signal defect (dDEG) is detected if the equivalent BER exceeds a pre-set threshold of 10E-X, where X=6, 7, 8 or 9. The dDEG is cleared if the equivalent BER is better than 10E-(X+1), according to ITU-T G.806. The thresholds are individually configurable for the different objects, from 10E-6 to 10E-9.

The number of simultaneous probes supported in the system is 63.

SNCP Performance Parameters

AXXMETRO implements the following SNCP Performance Parameters:

- PSC (Protection Switching Count) is the total accumulated number of protection switching events
- PSD (Protection Switching Duration) is the accumulated time that the Protection path has been selected. PSD is only meaningful for revertive mode.
- Measured Time is the number of seconds since this protection instance was enabled.

PSC is incremented automatically each time a switch occurs. PSD and Measured Time are updated once each second.

The parameters are cleared when the protection instance is disabled or if a "ClearAllPmData" command is issued from the operator.

Equipment protection switching performance parameters

AXXMETRO offers the following switching parameters:

- PSC (Protection Switching Count) is the total accumulated number of protection switching events
- Measured Time is the number of seconds since this protection group was created

PSC is incremented automatically each time a switch occurs. Measured Time is updated once each second. The parameters are cleared when the protection group is disabled or if a "ClearAllPmData" command is issued from the operator.

MSP 1+1 performance parameters

AXXMETRO implements the following MSP 1+1 Performance Parameters:

- PSC (Protection Switching Count) is the total accumulated number of protection switching events
- PSD (Protection Switching Duration) is the accumulated time that the Protection link has been selected. PSD is only meaningful for revertive mode.
- Measured Time is the number of seconds since this protection instance was enabled.

PSC is incremented automatically each time a switch occurs. PSD and Measured Time are updated once each second. The parameters are cleared when the protection instance is disabled or if a "ClearAllPmData" command is issued from the operator.

Pointer justification performance parameters

AXXMETRO offers pointer justification performance parameters, PJE for the following objects:

- AU-4
- AU-4-2c
- AU-4-4c
- AU-4-8c
- AU-4-16c

PJE, both positive and negative justifications, are counted and measured over a 24-hour interval. Both current and past 24hour interval counters are available.

In addition to the PJE counters, an alarm is raised if the number of PJEs over a 15-minute period is greater than a configurable number, PJEL (Pointer Justification Event Limit). The PJEL is configurable from 1 to 1024 events.

Port states

The SDH interfaces support the following administrative port states:

- In service (IS)
- Out of service (OOS) and this is the default state
- Out of service maintenance (OOS-MT)
- Out of service-Auto in service (OOS-AINS)

The IS state is the normal operation state, and in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is enabled
- Loops are not allowed to be activated

The OOS state is equivalent to a port shutdown, in this state the port operates in the following manner:

- The port is not able to carry traffic
- Alarm reporting is disabled for the port (includes also alarms related to configurable Physical Interface module)
- Loops are not allowed to be activated
- For optical SDH ports the laser is shut down
- For electrical STM-1 ports AIS is transmitted in the payload

The OOS-MT state is a port state intended for testing, fault finding and maintenance activities. In this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are allowed to be activated

The OOS-AINS state is a temporary state intended for provisioning purposes. This means that a port configured to OOS-AINS automatically goes into IS state if a valid signal is applied to the port. A valid signal is a signal that is clearing the LOS (Los of signal) alarm.

For a state change to occur, the signal must be valid for a certain time, which is a configurable parameter from 0 to 48 hours in steps of 15 minutes. The parameter is a global parameter for the whole NE.

In the OOS-AINS state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are not allowed to be activated

Loopbacks

SDH loopbacks

The AXXMETRO supports both Line and Terminal loopbacks as shown in the figures below.

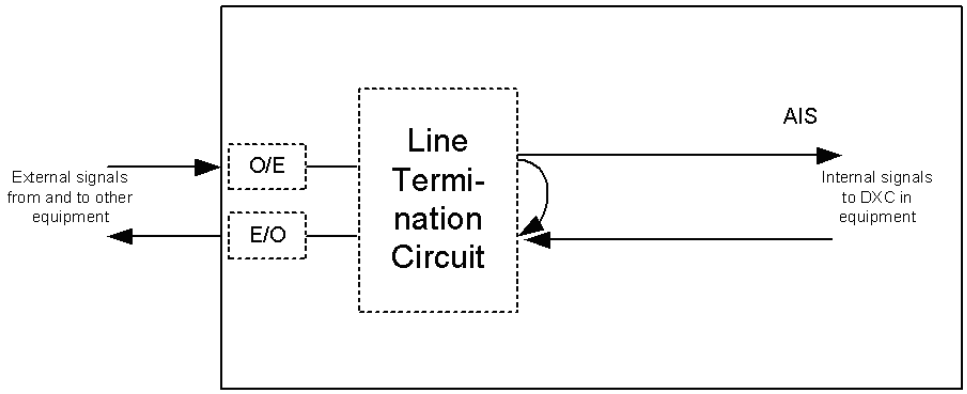


Figure 2-20. Line loopback

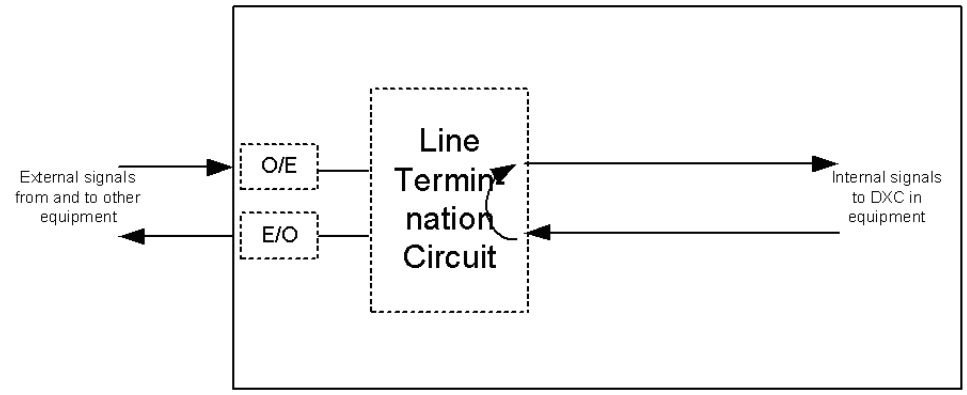


Figure 2-21. Terminal loopback

The SDH line loopback has the following characteristics:

- Only the payload is looped back
- RSOH and MSOH is not looped back but terminated
- The output signal is locked by the T0 reference clock
- AIS is inserted towards the matrix
- The port does not need to be structured
- The loopback can only be configured when the port state is OSS-MT

The SDH Terminal loopback has the following characteristics:

- Only the payload is looped back
- RSOH and MSOH is not looped back, but terminated at the RX side
- AIS is inserted in the payload towards the line interface

- The loopback can only be configured when the port state is OOS-MT

Electrical loopbacks, PDH ports

Two different electrical loop backs are available in AXXMETRO:

- Line loopback (facility loopback)
- Terminal loopback

The two loopbacks are allowed on PDH ports configured in the following modes:

- TRA
- G.704
- G.704_fixed

The two loopback definitions are shown in the Figure 2-20. and Figure 2-21.

The PDH line loopback (facility loopback, LL3) is performed in the VCT circuits, the loop has the following characteristics:

- The entire PDH E1 or E3 signal is looped back
- The loopback is performed after the clock extraction
- AIS is inserted towards the network element itself
- The loopback can only be configured when the port state is OSS-MT

The PDH Terminal loopback (LL2) is performed VCT circuits, the loop have the following characteristics:

- The entire PDH E1 or E3 signal is looped back towards the network element itself
- AIS is transmitted towards the line at nominal rate

The loopback can only be configured when the port state is OOS-MT

Synchronisation

Functional Requirements

AXXMETRO conforms to ETSI ETS 300 417-6-1 regarding requirements specified for a SEC device. AXXMETRO also conforms to ITU-T Recommendation G.781.

Functional Model

The model in Figure 2-22. illustrates the internal AXXMETRO functionality related to synchronization. The following sections describe some of these blocks in more detail.

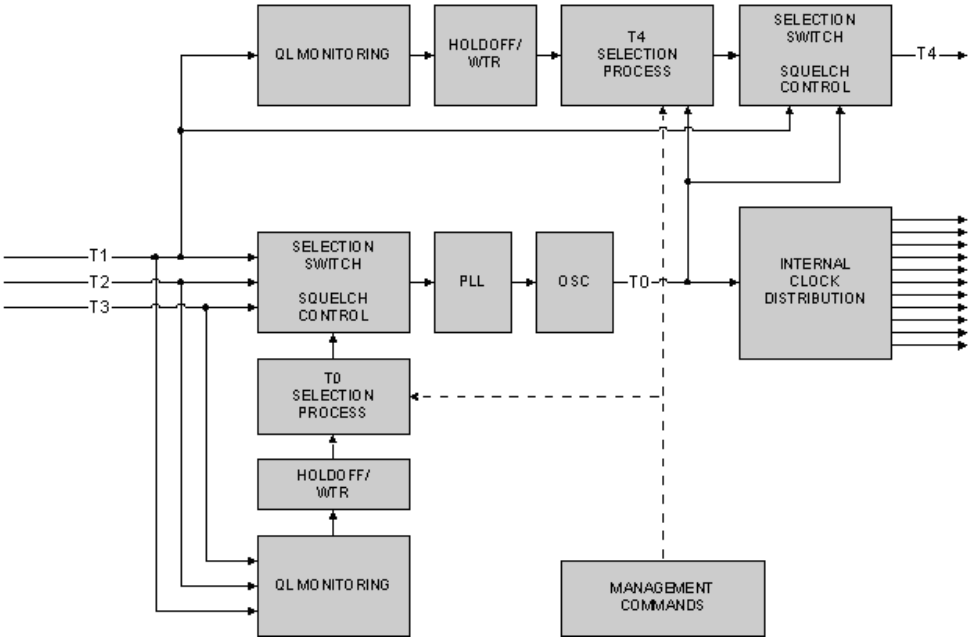


Figure 2-22. Sync functional model

The AXXMETRO contains a T0 synchronization selection process operating in QL-enabled mode. The process is responsible for selecting the best signal source to be used as reference input for the SETS generating the T0 clock. The selection is done among a number of nominated sources (within the signal types T1, T2 and T3) as configured by the network operator.

In the free-running mode, the T0 clock complies with the SEC clock requirements as described in ITU-T Recommendation G.813. When operating in the locked mode, the internal oscillator output (T0) is aligned to the selected reference source. This frequency in turn applies to all egress STM-N signals (going out from the NE).

The AXXMETRO also contains a selection process responsible for selecting the reference source for the T4 ports (which is the synchronization output port). This selection is done among ingress T1 signal sources contained in a selection list. The T4 output ports can also be locked to the internal T0 clock.

Sync Interfaces

Each of the reference points T1, T2 and T3 discussed above contain one ore more signals applicable for synchronization purposes. For the AXXMETRO, the following interface types apply to the synchronization selection processes:

T1 inputs:	STM-N signals (N = 1, 4, 16) with or without SSM (S1 used for carrying QL)
T2 inputs:	2.048 Mbps signals (E1) in G.704 framed mode
T3 input:	2.048 MHz or 2Mbps (configurable) external synchronization signal (T12) derived from a station clock

The operator configures the signal reference candidates associated with each of the two (T0, T4) selection processes.

QL Support

The referred synchronization reference signals may or may not provide in-band QL provisioning (SSM). As the internal selection processes operate in QL enabled mode with synchronization sources of both categories, the operator must configure whether or not each synchronization source candidate supports SSM. If it does, the received SSM is used for obtaining the corresponding QL. If SSM is not supported, the operator must assign a fixed QL for the corresponding reference signal. The selection process uses the QL when there are no signal failures (alarms or faults) associated with the reference signal.

Hence, the total performance (QL) for a synchronization source depends on the following parameters:

- The signal condition
- The in-band SSM (if enabled) or assigned QL-level (if in-band SSM usage is disabled)

A signal failure condition is defined as any of the following alarms:

For STM-N ports:	LOS, LOF, RS-TIM, MS-AIS
For E1 ports:	LOS, AIS, LFA

If supported, the QL of a signal candidate is carried in-band by means of the SSM. For STM-N links the S1-byte (in MSOH) is used for this purpose. For E1 ports, the SSM can be carried as a four-bit code formed by the contiguous Sax1-Sax4 bits within a G.704 SMF. Any of the Sax-bits (x = 4, 5, 6, 7, 8) can be used for this purpose.

The AXXMETRO provides two separate 2.048 MHz or 2 Mbps interfaces (T4) to which other NEs can be synchronized, either directly or via a SASE as described in ITU-T Recommendation G.803 appendix III.7.1, SSM. The T4 outputs support SSM when configured in 2 Mbps G.704 modes.

The two outputs are controlled by one common T4 selection process.

Sync Table

For the T0 selection process, the AXXMETRO maintains a table containing up to 5 possible synchronization signal candidates. Each entry in this table contains the following information:

- Identification of the synchronization source candidate (via its slot number, port number etc.)
- Whether SSM usage is enabled for the corresponding candidate. If SSM is not enabled, the operator is free to assign a fixed performance code (QL) to be used by the selection process when there are no alarms associated with the reference signal. Refer to ETS 300 417-6-1 § 4.4.3.
- The corresponding priority for the corresponding candidate. This priority applies only when there are multiple candidates all having the highest QL among all possible source candidates.
- Hold-off timer, configurable parameter with a value in the range 300-1800 ms. Refer to ETS 300 417-6-1 § 4.8.
- Wait To Restore timer, configurable parameter with a value in the range of 0-12 minutes (one minute step)

For the T4 selection process, the AXXMETRO maintains up to 5 possible synchronization source candidates. External synchronization candidates must be of the T1 type (STM-N).

However, another legal candidate for the T4 selection process is the internal T0 clock. Hence, T4 can be locked either to an arbitrary T1 (STM-N) port or the internal T0 clock. Applicable ports (among the T1 candidates) are configured by the operator and stored in a table with the same parameters as for the T0 selection process.

If the QL of the selected signal source falls below a configurable minimum threshold (QLM), the T4 output is immediately squelched.

Searching for an alternative reference source is started when the hold-off time for the signal has elapsed. Selecting a new T4 reference source is done provided that the QL of the candidate equals or exceeds the QLM value.

Multiple ring support and ring interconnection

The AXXMETRO is able to support multiple ring configurations in one network element. In this release only SNCP is supported as a ring protection mechanism.

The number of simultaneously supported SNCP rings in one network element is up to 12 STM-1, 12 STM-4 or 4 STM-16 rings. The supported number in an actual application may be less due to the capacity of the lower-order matrix (equivalent to 96x96 VC-4).

Virtual rings

The AXXMETRO supports Virtual rings. A virtual ring is one logic ring running across multiple physical ring structures, the protection scheme used is SNCP. Virtual rings can be created with both unidirectional and bidirectional cross connect. Spans of different line rates can be mixed together in virtual rings as long as the SNCP connection is done at the same level.

Single node interconnection

The AXXMETRO supports single node interconnection. A node is the same as a network element. Single node interconnection is an architecture between two rings where one node in each ring is interconnected. The single node interconnection is according to ITU-T G.842 clause 6.1. This architecture, shown in Figure 2-23. has a single point of failure at the point where the rings are interconnected. Interconnection protection can be provided by multiplex section protection of the interconnecting span, but no protection is available due to failure of either interconnecting node.

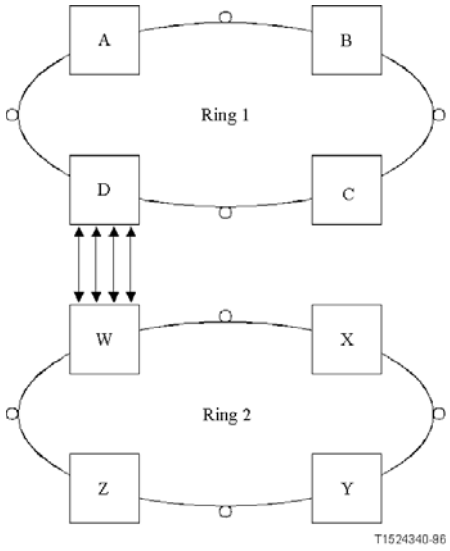


Figure 2-23. Single node interconnection

Dual node interconnection

The AXXMETRO supports dual node interconnection.
Dual node interconnection is an architecture between two rings where two nodes in each ring are interconnected as illustrated in Figure 2-24. The two interconnections between the two rings can be arranged to provide protection of the traffic crossing from one ring to the other. A special form of

dual node interconnection is given the term ring interworking. Ring interworking is a network topology whereby two rings are interconnected at two nodes on each ring, and the topology operates such that a failure at either of these two nodes does not cause loss of any working traffic.

The dual node interconnection is according to ITU-T G.842 clause 6.2.3.

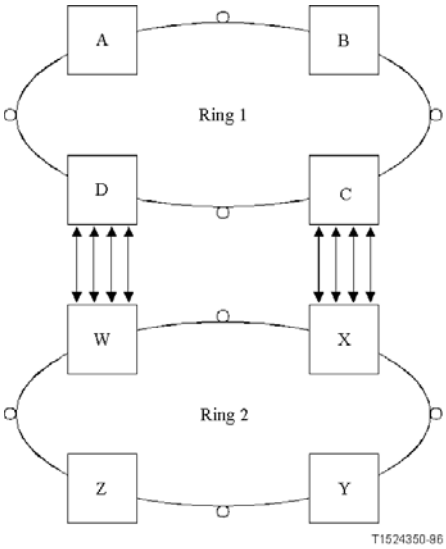


Figure 2-24. Dual node interconnection

Auxiliary interface for SDH overhead bytes

The AXXMETRO offers two proprietary Auxiliary interfaces for termination of overhead bytes selected from the different STM-N interfaces. Each STM-N interface can be configured to terminate one of the following overhead bytes:

- E1
- F1
- E2

NOTE! **AXXMETRO does not support the F2 and F3 bytes.**

The byte to be terminated is selected from the TMN system together with a unique timeslot number n, where n can be from 1-31. The maximum number of bytes that can be terminated is 31.

The Auxiliary interface is a framed E1 interface according to ITU-T G.704, where timeslot 1-31 can carry one overhead byte each, according to the configuration described above.

The interface is synchronous, which means that the incoming STM-N need to be synchronised with the T0 reference clock in the AXXEDGE and the incoming framed E1 needs to be synchronised with the outgoing framed E1. Bit slips will occur if one of the interfaces is free running.

2.2 ETHERNET OVER SDH MAPPING

AXXMETRO supports two different modes of Ethernet over SDH (EOS) mapping:

- AXXESSIT proprietary mapping combined with inverse multiplexing at VC-12 level.
- GFP-F mapping combined with VCAT, at VC-12, VC-3 and VC-4 level, and LCAS.

The EOS mapping functionality is module dependent and EOS mapping is supported on the following modules:

- 8xFE-16xMAP-SFP
- 2xGE-2xMAP-SFP

2.2.1 AXXESSIT proprietary mapping

The AXXMETRO provides a proprietary mapping scheme for mapping of Ethernet traffic into a number of VC-12 containers.

The HDLC encapsulated Ethernet frames are mapped into a number of VC-12 containers in a round-robin fashion with an inverse multiplexer function.

A total differential delay of up to 8ms is supported.

The total bandwidth for one WAN channel is 100 Mbps or 50xVC-12 containers. The AXXESSIT proprietary VC-12 mapping scheme for Ethernet takes advantage of 2,16 Mbps in each VC-12, which means that 47xVC-12s are sufficient to transport 100MbpsEhernet.

The VC-12 K.L.M reference assignment for the Ethernet WANx port is fully flexible, and controlled in the same way as a VC-12 cross connect.

The sequence number attached to each VC-12 is used for alarm indication only in case of a sequence mismatch, the sequence number is not used for reordering the incoming VC-12s. The order of VCs carrying Ethernet traffic between two WAN-ports therefore needs to be maintained.

In case of a failure on one of the VC-12s, the effected VC-12 is removed from the channel, allowing the traffic to flow on the remaining VC-12 connections. RDI is used to indicate a failure to the remote side.

READ MORE: **“AXXESSIT proprietary mapping of HDLC frames” on page 2-5.**

2.2.2 Standardised mapping

AXXMETRO supports standardised ways of mapping Ethernet over SDH. The mapping schemes include mapping protocol, concatenation scheme and control protocols.

GPF

GFP General requirements

AXXMETRO supports framed mapped GFP (GFP-F) according to ITU-T G.7041.The GFP implementation supports the following functions:

- The implementation only supports GFP null extension header
- Client data frames are supported
- Client management frames are supported
- For control frames, the implementation only supports GFP idle frames insertion and processing, other unspecified control frames will be dropped
- Standard GFP scrambling is supported, with the polynomial 1+x43
- The implementation supports the optional data FCS insertion and checking via the PFI bit
- The implementation supports frame sizes from 64 bytes up to 9 Kb

READ MORE: Mapping of GFP frames in VC-x containers is described in "Mapping of GFP frames" on page 2-4

GFP Alarm and Event Conditions

The GFP implementation supports the following alarm and event conditions:

- GFP Frame Delineation Loss Event, LFD
- Payload Mismatch, PLM
  - Alarm based on detection of PTI field value in ITU-T G.7041
- User Payload Mismatch, UPM
  - Alarm based on detection of UPI field value in ITU-T G.7041
- Payload FCS Mismatch, PFM
  - Alarm based on detection of PFI field value in ITU-T G.7041
- Extension Header Mismatch, EXM
  - Alarm based on detection of EXI field value in ITU-T G.7041

GFP Performance Monitoring

The GFP implementation collects the following performance parameters:

- Total number GFP frames transmitted and received
- Total number Client management frames transmitted and received
- Number of bad GFP frames received, based upon payload CRC calculation
- Number of cHEC corrected errors
- Number of cHEC uncorrected errors
- Number of tHEC corrected errors

- Number of tHEC uncorrected errors
- Number of Dropped GFP frames in GFP receiver

A degrade alarm is available for the following performance parameters:

- Number of bad GFP frames received, based upon payload CRC calculation, degFCS
- Number of tHEC corrected and uncorrected errors, degtHEC

The deg alarms are handled in a similar way as the SDH degrade alarms.

VCAT and LCAS

VCAT and LCAS General requirements

AXXMETRO supports virtual concatenation according to ITU-T G.707. The support of VCAT is dependent on module type. The VCAT implementation supports the following functions:

- FE (Fast Ethernet) mapper interface
    - VC-12-nV, where n=1..50
    - VC-3-nV, where n=1..3
    - VC-4-nV, where n=1
- GE (Gigabit Ethernet) mapper interface
    - VC-3-nV, where n=1..21
    - VC-4-nV, where n=1..7

The VC-x level is individually configurable pr. mapper port. A mix of different VC-x levels in one Virtual Concatenation Group (VCG) is not allowed.

A total differential delay of up to 62ms is supported for the different VCGs.

AXXMETRO supports the LCAS protocol in conjunction with VCAT as defined in ITU-T G.7042. The LCAS protocol implemented covers the following functions:

- Automatic temporary removal of a faulty VCG member
- Automatic hitless insertion of a temporary removed VCG member when the fault is repaired
- Hitless increase of the VCG capacity by adding a VCG member
- Hitless decrease of the VCG capacity by removing a VCG member
- Inter-working with equipment supporting VCAT but not supporting LCAS

VCAT and LCAS configuration modes

The AXXMETRO offers two different operation modes for the VCAT and LCAS functionality, the two modes are:

1. VCAT with LCAS enabled
2. VCAT without LCAS enabled

Mode 1:

VCAT with LCAS enabled is always uni-directional, which enables the possibility to have different capacity in each direction but requires a separate cross connect/capacity setup in each direction.

Mode 2:

When VCAT is used without LCAS there is no mechanism for removing of a faulty VC container in a VCG. To solve this problem the AXXMETRO implements, in addition to the standard mode, a proprietary mode.

The following configurations are available in mode 2:

- Same features as in mode 1 but without LCAS
- SoftLCAS mode

If SoftLCAS mode is enabled, the cross connections is not uni-directional, but bi-directional. In addition RDI signalling is enabled. A faulty container in a VCG is removed based upon the VC alarm condition or based upon RDI signalling (similar to AXXESSIT proprietary mapping). This allows a VCG to continue operation even if the VCG has a failed member.

The SoftLCAS configuration mode is proprietary.

VCAT and LCAS Alarm and Event Conditions

The following alarms related to the VCAT and LCAS are reported by default:

LOM	VCAT, loss of multiframe
SQM	VCAT sequence indicator mismatch
LOA	LCAS loss of alignement for channels with traffic
GIDERR	LCAS Group Id different for active channels
LCASCRC	LCAS CRC error detected
NONLCAS	LCAS non-LCAS source detected
PLCR	LCAS partial loss of capacity receive
TLCR	LCAS total loss of capacity receive
PLCT	LCAS partial loss of capacity transmit
TLCT	LCAS total loss of capacity transmit
FOPR	LCAS failure of protocol
SQNC	Inconsistent SQ numbers

In addition to the above default alarms, the following alarms are available if enabled from the management system:

acMstTimeout	LCAS acMst timeout
rsAckTimeout	LCAS RS-ack timeout
eosMultiple	LCAS two or more channels have EOS
eosMissing	LCAS one channel has EOS
sqNonCont	LCAS missing SQ detected in set of channels
sqMultiple	LCAS equal SQ for two or more channels
sqOor	LCAS SQ outside of range
mnd	LCAS member not de-skewable
ctrlOor	LCAS undefined Ctrl-word for one or more channels

2.3 ETHERNET FEATURES

2.3.1 General information

The AXXMETRO includes Ethernet interfaces. It can support both Ethernet tunneling (L1) and Ethernet switching (L2) depending on what type of Ethernet modules that are inserted in the shelf. Some modules support tunneling, some support switching and some supports both tunneling and switching.

NOTE! **The terms bridge and switch have the same meaning in this document. The fact the bridge has several ports makes it a multi-port bridge or a switch.**

The modules that support tunneling contain a number of Ethernet interfaces and mappers. The mappers are used to map the Ethernet traffic into SDH. The number of interfaces and mappers depend of the selected module. See specific details in the description of the available modules.

The modules that support switching contain an Ethernet switch in addition to the Ethernet interfaces and the mappers.

The aggregate modules contain an Ethernet crossbar to make is possible to interconnect the different Ethernet switches on the modules so you can switch traffic between the different modules without using SDH capacity.

The external ports are termed LANx ports. They are attached to the physical LAN connectors of the device.

The internal ports of the switch that are connected to the mappers are termed WANx ports. For each of the WANx ports, the WAN mapper can create a channel for the port's Ethernet traffic in the SDH aggregate interface. Such a channel consists of a configurable number of virtual containers. The Ethernet traffic on the WANx port in question is mapped into the payload of the virtual containers,

and the number of VCs selected decides the bandwidth of the channel. The mappers have the capacity of mapping a full 100 Mbps or 1000 Mbps WAN interface into virtual containers.

The fact that some of the ports of the bridge are connected to long distance channels makes the AXXMETRO a remote bridge. The combination of two AXXMETROs on different geographical sites with a WAN channel between them, can be viewed as a single bridge with LANx ports at each site.

2.3.2 Ethernet services

AXXMETRO delivers a number of different Ethernet services as described in the following four chapters.

Ethernet Private Line

The Ethernet private line (EPL) is the simplest of the Ethernet services. It is a point-to-point connection between the AXXMETRO and a remote network element as shown in the figure below. The Ethernet traffic is mapped into virtual containers and transported through the SDH network. The remote NE must support standard GFP and virtual concatenation or use one of the proprietary mapping schemes supported by AXXMETRO.

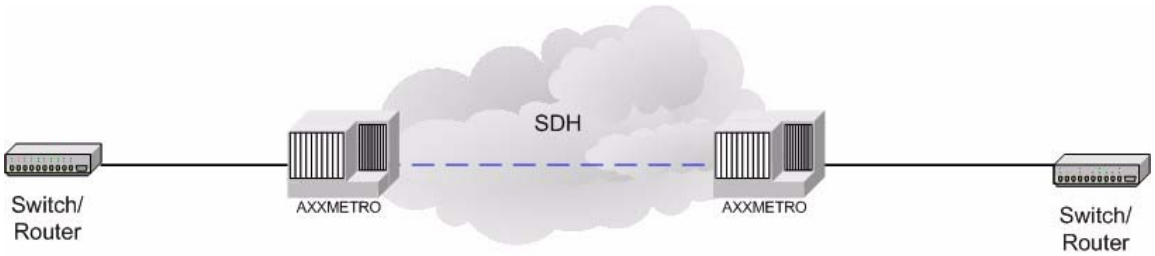


Figure 2-25. Ethernet Private Line service

This is an L1 service and the Ethernet frame is not processed. Some basic error checking of the Ethernet frames is performed (e.g. checking FCS, wrong Ethernet format, undersized packets or too big packets).

The capacity of the WAN channel sets the maximum capacity of the service. It is possible to use rate limiting to reduce the traffic capacity of the EPL below the WAN capacity. This makes it possible to change the capacity of the customer traffic without affecting the SDH network.

Non-conforming traffic can be treated in two different ways:

- By using flow control to prevent buffer overflow
- By dropping packets when the buffer is full.

Priority may be used to make it possible for high priority packets to bypass low priority packets in the buffer.

Performance monitoring is available with the RMON counters for the Ethernet part and SDH performance monitoring for the SDH part.

The physical interface can be either a FE port or a GE port and the AXXMETRO supports a number of different physical interfaces (See module description chapter and interface description chapter).

It is possible to have multiple EPL services active in AXXMETRO. The number is limited by the total aggregate capacity, the number of mappers and the number of physical Ethernet interfaces. The different Ethernet services can be routed in different directions in the network.

It is also possible to create LAN services with multiple EPLs. A network topology based on mesh (a) and hub and spoke (b) are shown in the figure below.

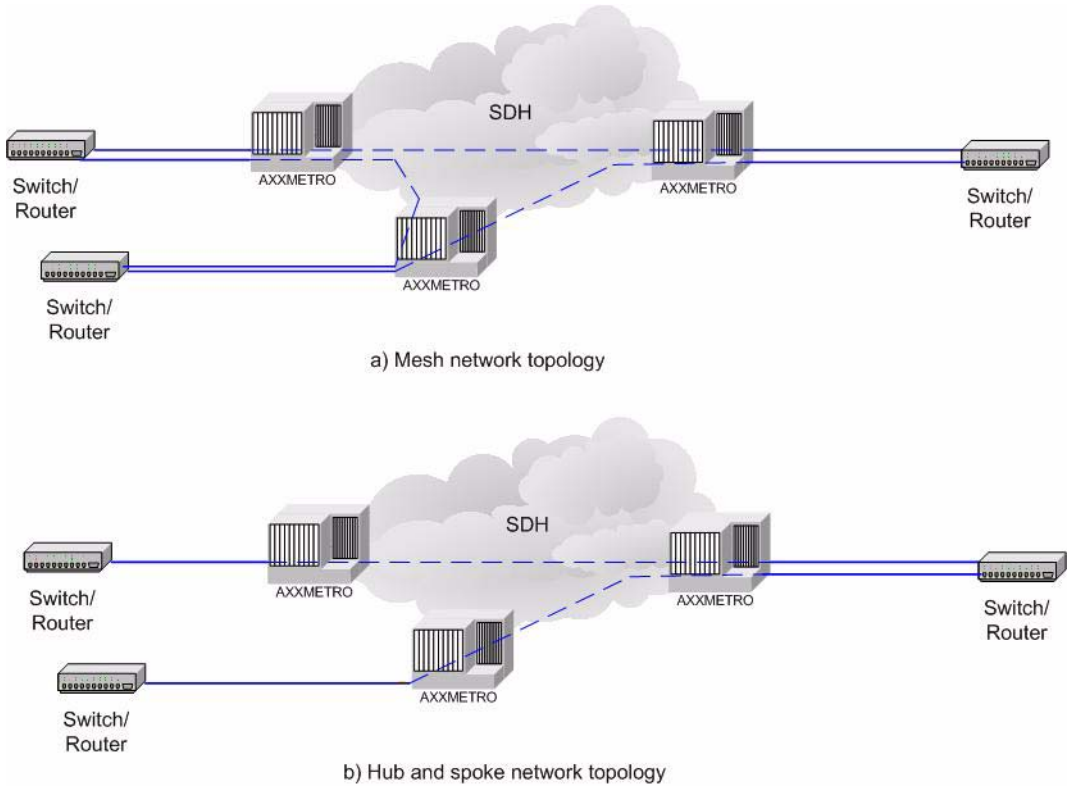


Figure 2-26. Network topologies for LAN based on EPL

Ethernet Virtual Private Line

Ethernet Virtual Private Line (EVPL) is essentially an EPL service where the data streams from multiple customers share a common transport network resource. The shared resource is typically the bandwidth of a transport channel where the sharing allows an increase in transport network bandwidth efficiency through statistical multiplexing of the client data frames. An example of EVPL with shared bandwidth is shown in the figure below.

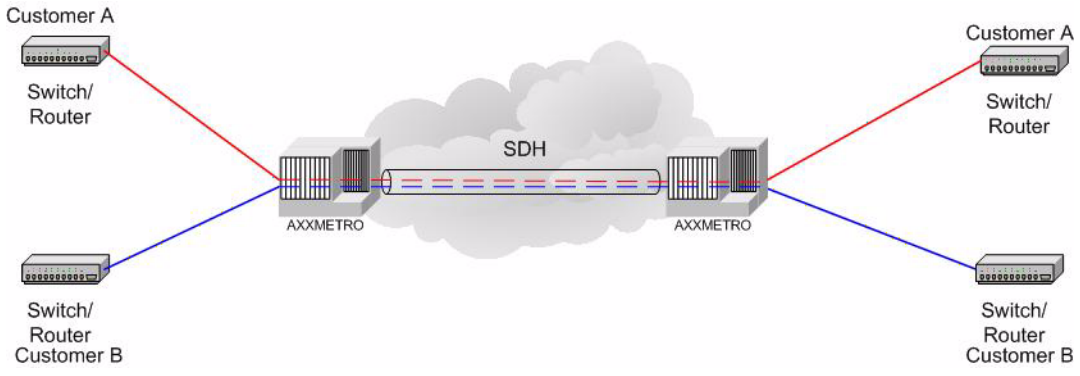


Figure 2-27. EVPL service

This is still a L1 service, but L2 switching capability is used for the grooming of the different customers. The capacity of the WAN channel sets the capacity of the service. Some basic error checking of the Ethernet frames is performed (e.g. checking FCS, wrong Ethernet format, undersized packets or too big packets).

The capacity of the WAN channel sets the maximum capacity of the service. Rate limiting is used to control the traffic capacity of the individual EVPL. The WAN capacity must be higher that the sum of all EVPLs that are using this WAN channel.

The statistical multiplexing of the traffic from the different customers is performed at the Ethernet layer.

Double tagging is used to transport the traffic from the different customers transparently through the network. The provider is inserting an additional VLAN tag that is unique for the customer. The VLAN tag is used to separate the traffic from the different customers.

L2 protocol tunneling is also used to transport the L2 control protocols from the customers (e.g. STP).

Rate limiting is used to police the ingress Ethernet traffic from the different customers to make it possible to meet the agreed service level agreements (SLA). Non-conforming traffic is remarked with lower priority. The non-conforming traffic is dropped if there is congestion in the network. It is also possible to drop non-conforming traffic without remarking the packets.

NOTE! **The full Ethernet rate limiting and re-marking are supported in a later release.**

Non-conforming traffic can be treated in two different ways:

- By using flow control to prevent buffer overflow
- By dropping packets when the buffer is full.

Priority may be used to make it possible for high priority packets to bypass low priority packets in the buffer.

Performance monitoring is available with the RMON counters for the Ethernet part and SDH performance monitoring for the SDH part.

The physical interface can be either a FE port or a GE port and the AXXMETRO supports a number of different physical interfaces (See module description chapter and interface description chapter).

It is possible to have multiple EVPL services active in AXXMETRO. The number is limited by the total aggregate capacity, the number of mappers and the number of physical Ethernet interfaces. The different Ethernet services can be routed in different directions in the network.

Ethernet Private LAN

An Ethernet Private LAN (EPLAN) provides LAN-type connectivity between multiple customer sites through dedicated channels. The next three figures illustrate some of the different basic

transport network topologies that can support this service. From the customer viewpoint, these topologies are equivalent (i.e. the carrier network architecture is transparent to the customer).

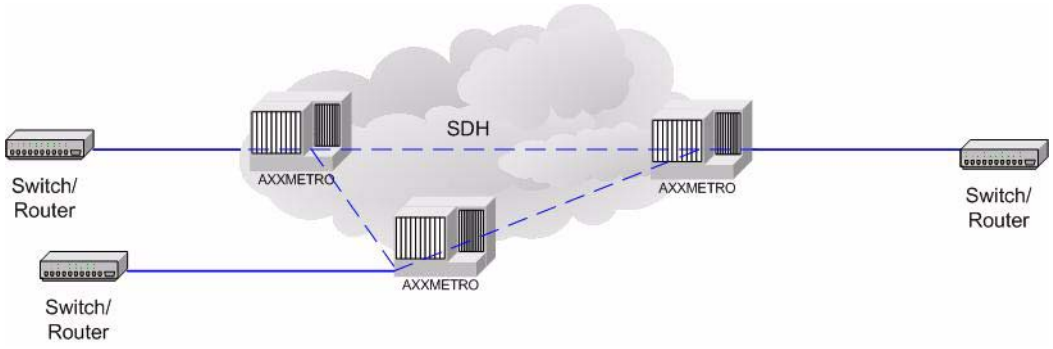


Figure 2-28. Ethernet Private LAN based on a meshed network topology

In Figure 2-28. and Figure 2-30. the carrier does the switching at the edge of the network. In Figure 2-30. the switching is done at one end of the network rather than at each end. In Figure 2-29. the traffic is brought to a centralized switch or a number of centralized switch points in a star connection.

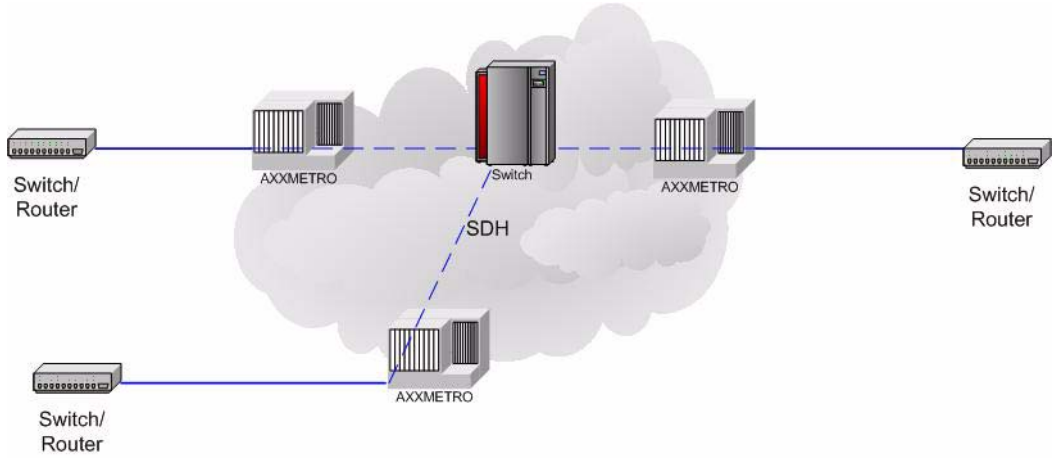


Figure 2-29. EPLAN based on a network topology with a centralised switch

EPLAN is an L2 service and the Ethernet frame is fully processed. Error checking of the Ethernet frames s performed (e.g. checking FCS, wrong Ethernet format, undersized packets or too big packets). The capacity of the WAN channel sets the capacity of the service.

Double tagging may be used to transport the traffic from the different customers transparently through the network. The provider is inserting an additional VLAN tag that is unique for the customer. The VLAN tag is used to separate the traffic from the different customers.

L2 protocol tunneling may also be used to transport the L2 control protocols from the customers (e.g. STP).

Rate limiting is used to police the ingress Ethernet traffic from the different customers to make it possible to meet the agreed service level agreements (SLA). Non-conforming traffic is re-marked with lower priority. The non-conforming traffic is dropped if there is congestion in the network. It is also possible to drop non-conforming traffic without re-marking the packets.

NOTE! **The full Ethernet rate limiting and re-marking are supported in a later release.**

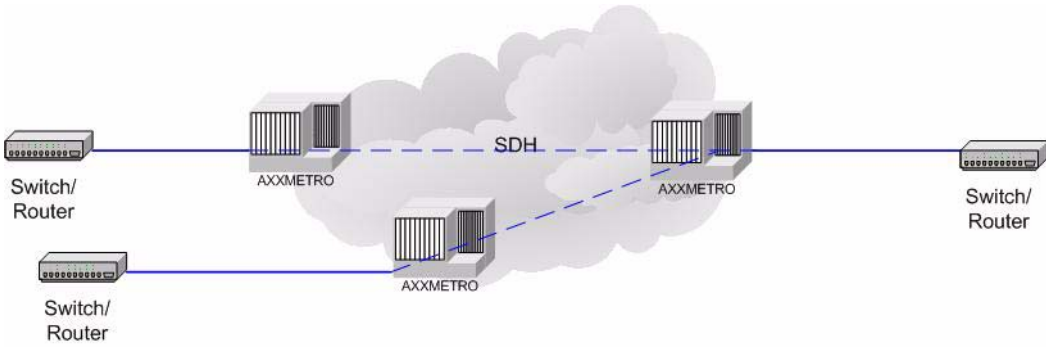


Figure 2-30. EPLAN based on a network topology with switching in an edge node

Priority may also be used to make it possible for high priority packets to bypass low priority packets in the buffers.

Performance monitoring is available with the RMON counters for the Ethernet part and SDH performance monitoring for the SDH part.

The physical interface can be either a FE port or a GE port and the AXXMETRO supports a number of different physical interfaces (See module description chapter and interface description chapter).

It is possible to have multiple EPLAN services active in AXXMETRO. The number is limited by the total aggregate capacity, the number of mappers and the number of physical Ethernet interfaces. The different Ethernet services can be routed in different directions in the network.

Ethernet Virtual Private LAN

EVPLAN is a combination of EVPL and EPLAN. The channel bandwidth is shared among different customers (as in Figure 2-26. b), the same are switches and/or routers in the carrier network. Ultimately, the sharing of bandwidth in the transmission channels and switch fabrics give EVPLAN the potential for very cost-effective carrier network resource use. However, EVPLAN is the most complicate network architecture to manage.

The functionality is more or less equal to EPLAN. The major difference is that double tagging and L2 protocol tunneling must be used to separate the traffic from the different customers.

The WAN capacity must be higher than the sum of guaranteed traffic from all customers.

Rate limiting is used to police the ingress Ethernet traffic from the different customers to make is possible to meet the service level agreements (SLA). Non-conforming traffic is re-marked with lower priority. The non-conforming traffic is dropped if there is a congestion in the network. It is also possible to drop non-conforming traffic without re-marking the packets.

Priority may also be used to make it possible for high priority packets to bypass low priority packets in the buffers.

Performance monitoring is available with the RMON counters for the Ethernet part and SDH performance monitoring for the SDH part.

The physical interface can be either a FE port or a GE port and the AXXMETRO supports a number of different physical interfaces (See module description chapter and interface description chapter).

It is possible to have multiple EVPLAN services active in AXXMETRO. The number is limited by the total aggregate capacity, the number of mappers and the number of physical Ethernet interfaces. The different Ethernet services can be routed in different directions in the network.

2.3.3 Ethernet functionality

Physical interface

Auto-negotiation

The LAN Ethernet ports on the AXXMETRO can operate at the traditional 10 Mbps Ethernet (E) speed, at the 100 Mbps Fast Ethernet (FE) speed or at the 1000 Mbps Gigabit Ethernet (GE) speed.

- FE copper ports support 10 Mbps and 100 Mbps line rates.
- FE optical ports support 100 Mbps line rate.
- GE copper and optical ports support 1000 Mbps line rate.

Each LANx port can operate in half duplex or full duplex mode. Half duplex means that transmission of traffic can occur in both directions on the wire, but only one direction at the time (the communicating parties take turns in sending on the wire). In full duplex, both parties can send and receive at the same time.

Each LANx port can use back pressure and flow control to deal with overflow so that frames do not get lost. Flow control is used on ports operating in full duplex mode. Back pressure is used on ports in half duplex mode.

Ports operating in half duplex mode do not use flow control. In stead they use back pressure to deal with overflow situations. A port experiencing overflow does not send pause frames upstream. Instead it sends a dedicated pattern upstream (JAM pattern), indicating a collision on the Ethernet medium. The pattern is sent continuously until the port is ready to receive more traffic. Other ports refrain from sending downstream traffic as long as the dedicated pattern endures.

The actual port parameters used are determined in one of two ways:

- Administratively - that is, an operator sets the port parameters to use, by means of the management system
- By auto-negotiation - that is, the AXXMETRO negotiates the port parameters to use with the equipment connected to the Ethernet port in question, according to the IEEE 802.3 specification.

All features may not be supported on a single LAN interface. Check with the relevant module description.

Auto-negotiation is by default active on all LANx ports.

The WANx ports are always set to 100 Mbps or 1000 Mbps depending of the type of mapper (FE or GE mapper).

The WANx ports are always set to Full Duplex.

Flow control can be symmetric or asymmetric. AXXMETRO supports symmetric flow control. This means that it can both originate pause frames when overflow is about to occur, and receive pause frames from other switches, and act accordingly.

AXXMETRO does not support asymmetric flow control.

Auto crossover

An Ethernet switch can be directly connected to a host with an ordinary Ethernet cable (e.g. UTP-5). If the switch is connected to another switch or a router, a crossover cable must be used. AXXMETRO supports auto crossover function that makes it possible to use either the crossover cable or the ordinary cable to hosts, switches or routers.

The auto crossover functionality in the Ethernet physical interface swaps the input signal with the output signal if a crossover cable is used.

The auto crossover feature is always enabled.

Ethernet frame size

The maximum frame size for L1 traffic is 9k octets.

The maximum frame size for Ethernet is 1522 octets. The size of the packets can be increase above this limit if a double tagging scheme such as Q in Q is used or if MPLS tags are added to the Ethernet frame.

The AXXMETRO supports oversized frames with sizes up to 6144 octets for L2 traffic. The default maximum frame size is 1536 octets.

NOTE! **The full Jumbo frames for GE (9K) is not supported for L2 traffic.**

MAC address

The physical ports have allocated a unique MAC address to each port.

LED indicators

The Ethernet copper interfaces have two LEDs to indicate the link status and speed of the link.

The link status LED indicates the following:

- The link is down if the LED is off
- The link is up if the LED is green
- The link is up and receiving or transmitting traffic when the LED is blinking green

The speed LED indicates the following:

- The link speed is 10 Mbps when the LED is yellow
- The link speed is 100 Mbps when the LED is green
- The link speed is 1000 Mbps when the LED is off

The Ethernet optical interfaces have only one LED. This is the link status LED. There is no link speed LED since the optical modules only support one link speed. AXXMETRO does not support multi rate optical modules for Ethernet.

The link status LED indicates the following:

- The link is down if the LED is off
- The link is up if the LED is green
- The link is up and receiving or transmitting traffic when the LED is blinking green

Forced LAN down

Forced LAN down is a feature that deactivates a LANx port if the WAN channel is down. Note that this feature is only available for L1 ports and is not supported for L2 ports.

Forced LAN down is switched off by default and can be activated from the TMN system.

MAC switching

AXXMETRO includes a transparent bridge with the following features:

- Promiscuous listening on all its ports and store and forwarding between ports
- Self-learning
- Spanning tree protocol (STP)

Promiscuous Listening and Store and Forward

Promiscuous listening means that the bridge listens to all traffic sent on all its ports, so that it can pick up any frames that should be sent on to other ports, and do so as appropriate.

The store and forward capability means the raw bits received on a port are not sent out on other ports immediately as they arrive thoughtlessly. Instead, the transparent bridge only picks up frames that should be sent to other segments. No forwarding to other ports is done until an entire, valid Ethernet frame has been collected. When forwarding on another segment, the bridge also applies to the medium access control on the segment.

Self-Learning

Self-learning means that the bridge is able to learn MAC addresses so that the bridge knows which segment a frame destined for a given MAC address should be forwarded to. The MAC address is stored in the table together with information about which port the segment in question is connected to.

This information can be used later, when a frame with the MAC address as destination address arrives at a different port. The bridge knows that the destination is reached through the registered port (directly or indirectly). Therefore, the bridge needs to forward the frame on that port only. Broadcast on all ports is avoided.

Static MAC addresses

Note that it is also possible to use static MAC addresses in AXXMETRO. The MAC address and the port number are added by a command from the TMN system. The static addresses are permanently placed in the MAC address table and the ageing algorithm does not affect them. The static addresses can be deleted by a command from the TMN system.

Administration of forwarding Cache

As seen in the previous sub-section, the transparent bridge capability implies that the AXXMETRO is able to learn MAC addresses and maintain them in a forwarding cache. If the cache gets full, new MAC addresses are flooded, and not learned.

To avoid that the cache is filled up with irrelevant MAC addresses, the AXXMETRO applies ageing to the entries in the cache. To ensure that the table gives as correct and efficient forwarding as possible, with limited superfluous broadcasting, MAC addresses that have been unused for a given time are removed from the cache.

Manual administration of the forwarding cache is also possible on the AXXMETRO. The management system offers commands for viewing the entire cache, viewing the size of the cache (that is the number of entries at any time), adding entries explicitly (static MAC addresses), editing entries and removing entries. Entries entered manually are not removed automatically by the system.

Through the TMN system it is also possible to configure the ageing time to be used, and to set a maximum size for the forwarding cache. For the latter, sizes up to 32K entries can be selected. The default size is 8K.

Head of Line Blocking prevention

The AXXMETRO switch has no Head Of Line Blocking (HOLB). The HOLB problem is described below.

A number of frames arrive in sequence at a port in a switch. Some are destined for a congested port and some for other non-congested ports. The switch with the HOLB problem processes incoming frames according to the FIFO (First In First Out) policy. The frames destined for the congested port wait in the buffer for access. Frames destined for non-congested port that arrive afterwards must also wait in the buffer until the congestion is removed. This introduces additional latency in the switch for the frames destined for the non-congested port.

If the congestion is not removed, the buffer fills up and the switch starts dropping frames. The frame dropping affects frames for both congested and non-congested ports. Dropping frames destined for the congested port is acceptable, but dropping frames for the non-congested ports is not acceptable.

VLAN

Overview

The Virtual LAN (VLAN) mechanism makes it possible to create several logical LANs on one physical LAN.

The VLAN is defined by a set of members. Members can be specified in a number of ways.

The most common way is the one used in port-based VLANs. In a port-based VLAN, a set of ports constitute the members of the VLAN. Each member is specified by the device (switch, hub, host) it belongs to and a port number on the device. A frame originated from the VLAN is communicated only on the ports that are members of that VLAN.

Communication between parties in a physical Ethernet is confined by the VLANs defined on the physical Ethernet. A frame sent on a VLAN is only distributed to members of the VLAN. The communication is confined to the members of the VLAN.

VLAN Access Links and VLAN Trunks

Because several VLANs can be defined on a single physical Ethernet, some physical links in the physical Ethernet may be used for traffic of several VLANs. Other links carry traffic from a single VLAN only, as shown in the example in Figure 2-31.

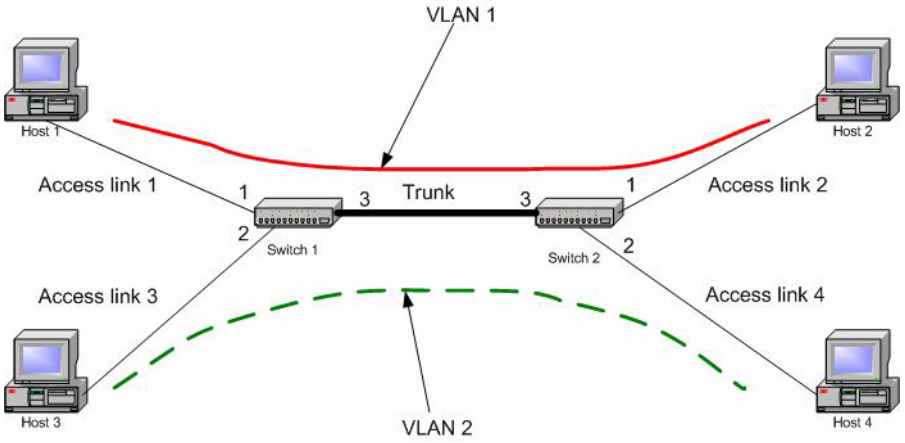


Figure 2-31. Small Ethernet with two VLANs, four access links and one trunk

The figure shows an Ethernet with two switches interconnecting four hosts. Two port-based VLANs have been defined:

- VLAN 1: defined by specifying port 1 and 3 of switch 1 and port 1 and 3 of switch 2 as members.
- VLAN 2: defined by specifying port 2 and 3 of switch 1 and port 2 and 3 of switch 2 as members.

The link between Host 1 and Switch 1 is called an access link. On an access link the VLAN an arriving frame belongs to can be uniquely identified without the use of tagging of frames on the link. In a port-based VLAN for instance, the VLAN of a frame on an access link can be decided implicitly from the switch port the link is attached to.

For a port- and protocol based VLAN, the VLAN for a frame on an access link can be decided from the switch port the link is attached to and the protocol number found in the Frame Type field of the frame header.

Access links connect VLAN unaware devices to the port of a VLAN aware switch. A VLAN unaware device is a device not able to handle VLAN tags.

The link between port 3 of the two switches is called a trunk because it carries traffic from more than one VLAN, and because tagging of frames is used on the port as needed to uniquely identify the VLANs of frames coming in on a port attached to the link.

Implemented features

The AXXMETRO supports VLANs according to the standard IEEE 802.1Q. Both access links and trunks are supported. The AXXMETRO can also handle trunks where one VLAN is untagged and the others are tagged. VLAN supported is:

- Port-based

The maximum number of VLANs is 4000. The supported VLAN id range is 1-4094.

By default, no LANx and WANx ports in L2 mode are included in a default VLAN, and all ports are untagged.

As with port-based VLANs, an Ethernet frame belongs to only one VLAN. In case a frame arrives at the switch and the device has no VLAN to which the frame is a member, the frame is discarded.

When a VLAN-tagged frame arrives at the switch, the AXXMETRO just looks up the VLAN on the device with the same tag as the tag found in the frame.

NOTE! **Both the MAC address and the VLAN tag are used in the lookup process. If such a VLAN is not found, the frame is discarded.**

When the AXXMETRO has received an Ethernet frame on a port and decided which VLAN the frame belongs to, the AXXMETRO sends the frame out on the ports listed as members of the identified VLAN (provided the ports satisfies the other basic Ethernet criteria for sending on the port).

GARP VLAN Registration Protocol

NOTE! **GVRP is not supported in the first release of the AXXMETRO.**

The Generic Attribute Registration Protocol (GARP) is a general-purpose protocol, specified in IEEE 802.1D, that is used by participants in GARP Applications (GARP participants) to register and de-register attribute values with other GARP Participants within a Bridged LAN. GARP defines a set of devices interested in a given network attribute, such as a VLAN address.

GARP VLAN Registration Protocol (GVRP) is specifically provided for automatic distribution of VLAN membership information among VLAN-aware bridges. GVRP allows VLAN-aware bridges to automatically learn VLAN to bridge ports mapping, without having to individually configure each bridge, and to register VLAN membership.

GVRP allows both end stations and Bridges in a Bridged LAN to issue and revoke declarations relating to membership of VLANs. The effect of issuing such a declaration is that each GVRP Participant that receives the declaration creates or updates a Dynamic VLAN Registration Entry in the Filtering Database to indicate that VLAN is registered on the reception port. Subsequently, if all Participants on a segment that had an interest in a given VID revoke their declarations, the port attached to that segment is set to Unregistered in the Dynamic VLAN Registration Entry for that VLAN by each GVRP Participant attached to that segment.

Use of static configuration of VLANs may be appropriate on ports where the configuration of the attached devices is fixed, or where the network administrator wishes to establish an administrative boundary outside of which any GVRP registration information is to be ignored. For example, it might be desirable for all ports serving end user devices to be statically configured in order to ensure that particular end users have access only to particular VLANs.

Use of dynamic configuration of VLANs may be appropriate on ports where the VLAN configuration is inherently dynamic; where users of particular VLANs can connect to the network via different ports on an ad hoc basis, or where it is desirable to allow dynamic re configuration in the face of Spanning Tree topology changes. In particular, if the "core" of the Virtual Bridged LAN contains redundant paths that are pruned by the operation of Spanning Tree, then it is desirable for Bridge ports that form the core network to be dynamically configured.

Use of both static and dynamic configuration of VLANs may be appropriate on ports where it is desirable to place restrictions on the configuration of some VLANs, while maintaining the flexibility of dynamic registration for others. For example, on ports serving mobile end user devices this would maintain the benefits of dynamic VLAN registration from the point of view of traffic reduction, while still allowing administrative control over access to some VLANs via that port.

Ethernet protection

Overview of Spanning Tree Protocol

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. Spanning-tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

The spanning-tree algorithm calculates the best loop-free path throughout a switched Layer 2 network. Switches send and receive spanning-tree frames, called bridge protocol data units (BPDU) at regular intervals. Switches supporting STP do not forward these frames, but use the frames to construct a loop-free path. Each switch uses the STP information in its own tables to create the BPDU it sends on to its neighbours. Switches not supporting STP forward the BPDU untouched, for its STP supporting neighbours to use.

Spanning tree defines a tree with a root switch and a loop-free path from the root to all switches in the Layer 2 network. Spanning tree forces redundant data paths into a standby (blocked) state.

When two interfaces on a switch are part of a loop, the spanning-tree port priority and path cost settings determine which interface is put in the forwarding state and which is put in the blocking state. The port priority value represents the location of an interface in the network topology and how well it is located to pass traffic. The path cost value represents the media speed.

NOTE! **Only a single instance of the spanning tree can be used regardless of VLAN configuration.**

Rapid STP

The RSTP mechanism adapts to changes in physical network topology (that is, links going down and coming up) faster than the traditional STP variant. The STP variant may use in the order of a minute to adapt to a change, while the RSTP adapts in less than a second.

RSTP may be used together with its corresponding traditional (slow) variant. Note that RSTP reverts to the STP algorithm on ports connected to equipment that only support STP.

AXXMETRO supports RSTP in according to the standard IEEE 802.1D (2004).

Multiple STP - (MSTP)

MSTP is not supported in release 1.0.

Traffic priority

Overview

IEEE 802.1p traffic priorities constitute a generic mechanism that can be used to give different priorities to different kinds of traffic. The priorities influences the way switches treats traffic coming in on their ports.

In a switch without priorities, all traffic destined for the output port is treated according to the FIFO policy. When more traffic arrives at the output port than can be sent, traffic is queued. The queue has a certain size. When the queue is full, frames have to be discarded or the traffic destined for the output port will have to be reduced.

With priorities, traffic can be categorized, and each traffic category can be assigned a specific priority. Traffic with the same priority is served FIFO.

The IEEE 802.1p priority mechanism uses eight priority levels, numbered 0 - 7, inclusive. The relative ranking between these levels is not fixed by the standard. There is however a recommended relative ranking and priority assignment to traffic types in the standard. See the recommendation in Table 2.4. below.

Priority Level	Traffic Type
7 (highest priority)	network management
6	voice
5	video
4	controlled load
3	excellent effort
0	best effort
2	undefined
1 (lowest priority)	background

Table 2.4. Relative ranking of priority levels and assignment to traffic types

In the table, the priority levels are given in the order of descending relative priorities.

NOTE! **The recommendation is to let priority level 0 (zero) have higher priority than 2 and 1.**

Most switches do not implement 8 queues per output port. Two or four queues per output port is more common. Having recognized this, the standard contains recommendations for how switches with less than 8 queues per output port should behave. A number of classes of service should be defined in such switches - one per output queue supported.

See the recommended mapping between priority levels and classes of service for such a switch in Table 2.5.

Priority Level	Class of Service
6, 7	3
4, 5	2
0, 3	1
1, 2	0

Table 2.5. Recommended mapping for a switch with four output queues per port

The AXXMETRO only supports strict priority as a scheduling policy that is applied between the queues at an output port:

- Strict policy: no traffic is sent from a queue with a given priority, unless all queues of higher priority are empty

For strict policy, the most distinctive advantage is that critical traffic can be sent at the same rate as it arrives at the queue with no traffic loss as long as the arrival rate is less or equal to the total capacity of the output port.

The priority of traffic arriving at a port of a switch can be determined implicitly or explicitly. In explicit determination, an arriving frame contains a tag explicitly stating the priority of the frame. The tag is a 3 bit field, part of the same overall tag-field as the one used for VLANs. Even though priorities and VLANs share an overall field of the Ethernet frame, they are independent mechanisms.

In implicit determination of priority the switch can tell the priority of an arriving frame from the context the frame is received in. The priority may for instance be determined based on which port of the switch the frame arrives on. In implicit determination, no priority tag is needed in the Ethernet frame

Implemented features

The AXXMETRO supports priorities according to IEEE 802.1p (802.1p was incorporated into the 802.1D). Four different classes of services are used - that is, four queues per output port. The classes of service are numbered from 0 through 3. Service class 0 has lowest priority. Priority increases with increasing service class number. The mapping from the 8 IEEE priority levels to the four classes of service is configurable through the management system. The default mapping used is the one recommended in IEEE 802.1D (see Table 2.5. above).

The scheduling used by the AXXMETRO between output queues at a port is strict policy. Both implicit and explicit (tagged) priority determination are used by the device. Tagging of outgoing frames with correct priority value is also supported, as is tag removal for outgoing frames (where appropriate).

The packet parts of the AXXMETRO include an Ethernet switch with a selectable number of ports. This decided by how many Ethernet modules are present in the system. The traffic priorities on the device work across all ports, as it would on a traditional Ethernet switch.

Rate limiting

Ethernet rate limiting

Ethernet rate limiting is not supported in this release.

SDH rate limiting

The rate limiting features for SDH are performed in the EOS mapper. The WAN capacity is used to set the maximum rate of the input port and the following step sizes are used.

- NxVC-12 for N is from 1 to 50
- NxVC-3 for N is from 1 to 21
- NxVC-4 for N is from 1 to 7

It is possible to map 2.24 Mbps into a VC-12 container 48.38 Mbps for a VC-3 container and 149.76 Mbps for a VC-4 container.

Bandwidth can be configured from 2.2 Mbps to 100 Mbps in steps of 2.2 Mbps with VC-12 mapping

Bandwidth can be configured from 48.4Mbps to 1000 Mbps in steps of 48.4 Mbps with VC-3 mapping

Bandwidth can be configured from 150 Mbps to 1000 Mbps in steps of 150 Mbps with VC-4 mapping

Provider bridging

The AXXMETRO provides some of the new provider bridging functionality.

It is important for a network provider to be able to deliver a transparent service to the end customer. Therefore it must be possible to tunnel the end customer traffic through the providers network without setting any requirements about the content of the end customer Ethernet traffic. The basic Ethernet format must of course be according to the Ethernet standards, but the end customer does not have any limitation on the VLAN information.

It is equally important to tunnel the user traffic to prevent the L2 control protocols from the end customer to interact with the operators network. Therefore it must be possible to remove or to tunnel the relevant control protocols through the providers network.

Provider VLAN also make the providers network more scalable by removing the 4K VLAN limitation and the size limitation of the spanning tree since the number of hops in the provider network is not a part of the calculations by the user spanning tree.

The new standard also introduces new OAM functionality.

tunneling of user traffic

tunneling of user traffic is supported with a Q in Q or double tagging solution. An additional VLAN tag is inserted in the ingress traffic when the Ethernet frame enters the providers network. The VLAN tag is removed from the egress traffic when the Ethernet frame leaves the provider network. Internally in the providers network it is treated as an ordinary VLAN Ethernet frame. The only difference is that the size of the Ethernet frame is increased with four bytes. This is shown in the figure below:

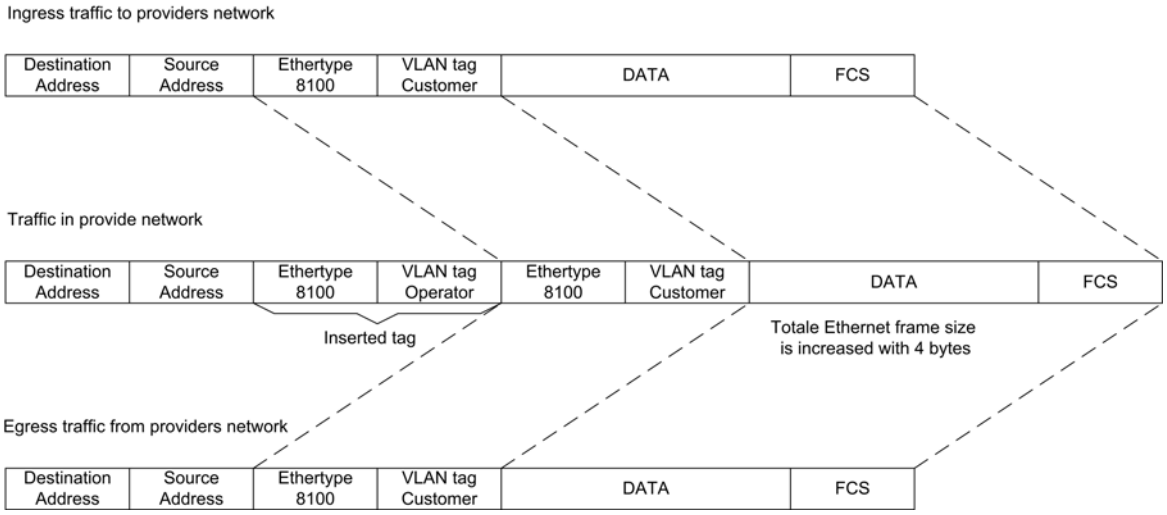


Figure 2-32. User traffic tunneling

The AXXMETRO supports two Ethertype values, 8100 and FFFF. The values are configurable from the TMN system.

The priority field in the provider tag can be set to a fixed value for a port or copied from the ingress customer traffic. This is selectable per port and controlled by the TMN system. The default setting is to copy it from the ingress customer traffic.

tunneling of user protocols

It is highly disadvantageous to mix L2 control frames (e.g. STP BPDUs) from the customer with the L2 control packet from the network provider.

The AXXMETRO can also tunnel user L2 control protocols through the provider network. The destination address for the protocol is replaced with a new multicast address from the AXXESSIT address range. The tunneling is performed between the ingress and egress of the providers network.

The following protocol can be tunneled:

- Spanning Tree Protocols (STP, RSTP and MSTP)
- IEEE 802.3x MAC Control Frames (PAUSE)
- Link Aggregation Control Protocol (LACP)
- IEEE 802.1x Port Authentication protocol
- Generic Attribute Registration Protocol (GARP)
- multicast to all bridges in a bridged LAN on standard address

It is possible to select from the TMN system if the control protocols are dropped, passed on or tunneled through the provider network.

Flow classification

There is very limited support for flow classification in this release. It is only possible to classify traffic on a per port basis.

Security

The security feature supported by AXXMETRO in this release is port locking.

It is possible to configure which host MAC addresses that are allowed to get access to the providers network. This is done with static MAC addresses from the TMN system. Ethernet frames with a source address that is not included in the static forwarding table are dropped.

Port locking is turned off by default.

Network authentication according to IEEE 802.1x or access control list are not supported in this release.

Performance monitoring

AXXMETRO provides performance monitoring based RMON statistic based on in IETF RFC 2819.

Functionality equivalent to the following groups are supported:

- Ethernet statistic group
- History control group
- Alarm group

The RMON functionality is available for all LANx and WANx ports.

Port states

The Ethernet interfaces support the following administrative port states:

- In service (IS)
- Out of service (OOS) and this is the default state
- Out of service maintenance (OOS-MT)
- Out of service-Auto in service (OOS-AINS)

The IS state is the normal operation state and in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is enabled

The OOS state is equivalent to a port shutdown and in this state the port operates in the following manner:

- The port is not able to carry traffic
- Alarm reporting is disabled for the port (includes also alarms related to configurable Physical Interface)
- The laser is shut down for Optical Ethernet ports

The OOS-MT state is a port state intended for testing, fault finding and maintenance activities. In this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled

The OOS-AINS state is a temporary state intended for provisioning purposes. This means that a port configured to OOS-AINS automatically goes into IS state if a valid signal is applied to the port. A valid signal is a signal that is clearing the LOS (Los of signal) alarm.

For a state change to occur the signal must be valid for a certain time, which is a configurable parameter from 0 to 48 hours in steps of 15 minutes. The parameter is a global parameter for the whole NE.

In OOS-AINS state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled

2.4 PDH FEATURES

2.4.1 E1 features

General information

AXXMETRO supports a number of E1 interfaces that is mapped into SDH VC-12 containers. The SDH mapping features are described in SDH features chapter.

The tributary modules do not include the physical connectors and must be used together with suitable connector modules (CM).

CMs are available with support for a different number of interfaces and different types of connectors.

The E1 interfaces provide a number of different services as shown below:

- Transparent leased line
- Framed leased line
- ISDN primary rate access (PRA)

It is possible to configure the E1 interfaces individually to support the different services.

AXXMETRO includes a special feature to reduce jitter and wander. The pointer processing for the interface is switched off and controlled frame slips are performed if the frequency of the SDH timing is not synchronised to the frequency of the PDH interface.

No frame loss, multiframe loss or CRC-4 errors are generated when controlled frame slips are performed.

This feature is only supported in the framed leased line and the ISDN PRA modes.

The total number of operational modes is five as shown below:

- TRA - Transparent leased line
- FRA - Framed lease line
- FRA-FIXED - Framed lease line with fixed pointer
- PRA - ISDN PRA lease line
- PRA-FIXED - ISDN PRA with fixed pointer

Transparent leased line

The transparent or unstructured leased line service delivers a full digital bit rate of 2048 kbps with no restriction on the binary content.

The service is symmetrical in both directions and supports point-to-point connections only. The service is specified in EN 300 247 and the network interface is specified in EN 300 418.

An alarm indication signal (AIS) is inserted towards the network if loss of signal (LOS) is detected from the customer.

AIS is also inserted towards the customer if LOS or other major alarms are detected from the networks.

Framed leased line

The framed or structured leased line service operates at a bit rate of 2048 kbps and provides an information transmissions capacity with no restriction on the binary content of 1984 kbps. The remaining 64 kbps provides an 8 kHz framing structure in accordance with G.704 and G.706.

The service is symmetrical in both directions and supports point-to-point connections only. The service is specified in EN 300 419 and the network interface is specified in EN 300 418.

It is possible to configure the service to run in both basic frame and multiframe modes.

NOTE! **Performance monitoring is only available in the multiframe mode.**

It is possible to terminate the CRC-4 segments in both directions, but it is also possible monitor the CRC-4 segments the CRC-4 bits and E-bits in both directions.

The SA bits and the A bit is not processed, and is undefined.

An alarm indication signal (AIS) is inserted toward the network if LOS, loss of basic frame alignment or loss of multiframe alignment is detected from the customer.

AIS is also inserted towards the customer if LOS, loss of basic frame alignment, loss of multiframe alignment or other major alarms are detected from the networks.

ISDN Primary rate access

Basic Configuration

ISDN Primary rate access (PRA) is used to provide ISDN access for the end customers of an operator. A block diagram describing the digital line section for PRA is shown in the figure below.

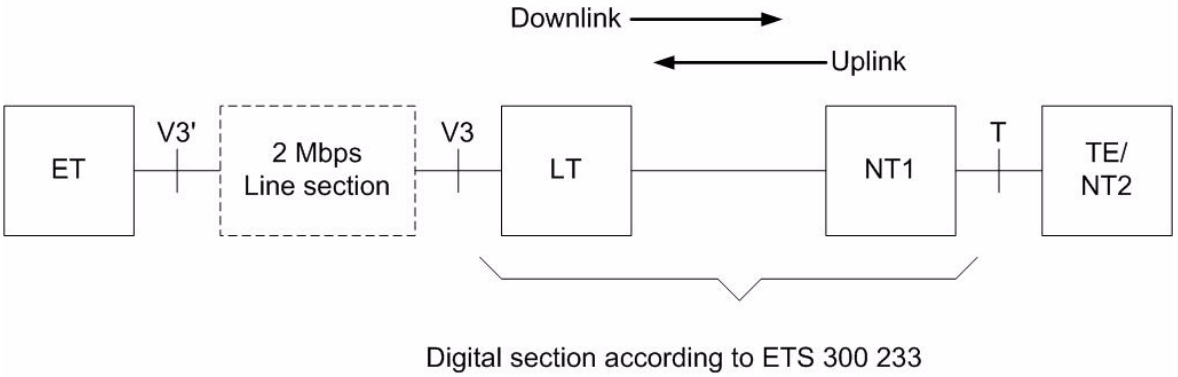


Figure 2-33. ISDN PRA

ET	Exchange Terminal
LT	Line Terminal
NT1	Network Terminal
TE/NT2	Terminal Equipment/Network Terminal 2 (users equipment)
T	Network Interface to user (ETS 300 011)
V3	LT interface to ET (ETS 300 233). If a 2 Mbps Line Section is inserted between LT and ET, the interface at the ET side is named V3

The interfaces related to the transmission between LT and NT1 are not specified, neither the transmission medium.

- Transmission rate at V3 and T is 2.048 kbps +/- 50 ppm with independent clocks for two directions of transmission
- Transmission format is according to G.704 and electrical interface according to G. 703 120 ohm balanced T interface.

The ET is responsible for management of the PRA access section. This is embedded in the functional specification of interface V3 comprising uplink reporting of failure conditions and detected bit errors and downlink provision of loopback commands.

The LT does not have any function related to supervision of transmission quality.

NOTE! **No LT1 functionality is implemented in AXXMETRO.**

The NT1 performs the following functions related to supervision of transmission quality:

- CRC-4 errors are detected and reported for the ET-NT1 CRC-4 segment using E-bits.
- CRC-4 errors are detected and reported for the NT1-TE CRC-4 segment using SA6 codes.
- Failure conditions are also reported using Sa6 codes.
- The NT1 is transparent to the following TS0 bits in both directions:
    - A(RA1),
    - SA4,
    - SA7
    - SA8.
- Bits SA5 and SA6 are utilised between NT1 and ET only, and are not interpreted by the TE

Loopback point 2 in the NT1 is specified towards the ET. Loopback commands are given from the ET by codes in TS0 bit SA6.

Performance monitoring

AXXMETRO measures and calculates performance monitoring data for bit errors in a G.704 framed signal.

A block of 2048 bits is used for detection of bit errors (one SMF). The embedded CRC-4 bits or the remote E-bits are used to detect bit errors in the block.

Three types of defects are defined in the specification:

- Loss of signal
- Detection of AIS
- Loss of frame alignment

Two type of anomalies are also defined:

- Error in frame alignment word
- Bit errors in the block

The following parameters are calculated according to G.826:

- Errored second (ES)
  A one second period with one or more errored blocks or at least one defect.
- Severely errored second (SES)
  A one second period which contains >= 30% errored blocks or at least one defect
- Background block error (BBE)
  An errored block not occurring as a part of an SES

- Unavailable seconds (UAS)
  A period of unavailable time begins at the onset of ten consecutive SES events. These ten seconds are considered to be part of unavailable time. A new period of available time begins at the onset of 10 consecutive non-SES events. These ten seconds are considered to be part of available time. UAS is the number of second of unavailable time.

AXXMETRO provides performance data for both CRC-4 segments and provides performance data for both CRC-4 errors and E-bits (remote CRC-4 errors).

NOTE! **The segment between AXXMETRO and the network is equal to the performance data for the VC-12 connection as long as the whole network is SDH based. It may differ if part of the network is running over PDH links.**

Port states

The E1 interfaces support the following administrative port states:

- In service (IS)
- Out of service (OOS) and this is the default state
- Out of service maintenance (OOS-MT)
- Out of service-Auto in service (OOS-AINS)

The IS state is the normal operation state, and in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is enabled
- Loops are not allowed to be activated

The OOS state is equivalent to a port shutdown, in this state the port operates in the following manner:

- The port is not able to carry traffic
- Alarm reporting is disabled for the port
- Loops are not allowed to be activated
- AIS is transmitted

The OOS-MT state is a port state intended for testing, fault finding and maintenance activities and in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are allowed to be activated

The OOS-AINS state is a temporary state intended for provisioning purposes. This means that a port configured to OOS-AINS automatically goes into IS state if a valid signal is applied to the port. A valid signal is a signal that is clearing the LOS (Los of signal) alarm.

For a state change to occur, the signal must be valid for a certain time, which is configurable parameter from 0 to 48 hours in steps of 15 minutes. The parameter is a global parameter for the whole NE.

In this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are not allowed to be activated

Loopbacks

Two types of loopbacks are supported for the interface:

- Line loopback
- Terminal loopback.

The PDH line loopback has the following characteristics:

- The entire PDH E1 signal is looped back
- The loopback is performed after the clock extraction
- AIS is inserted towards the network element itself
- The loopback can only be configured when the port state is OSS-MT

The PDH Terminal loopback has the following characteristics:

- The entire PDH E1 signal is looped back towards the network element itself
- AIS is transmitted towards the line

The loopbacks can only be configured when the port state is OOS-MT.

The loops can be activated from the craft terminal or from the TMN system. The network loop can also be activated in band from the ET in ISDN PRA mode.

TIP **It is not possible to activate the loops from the craft terminal or the TMN system while in ISDN PRA mode.**

2.4.2 E3 features

General information

AXXMETRO supports a number of E3 interfaces that are mapped into SDH VC-3 containers.

READ MORE: **SDH mapping features in “SDH features” on page 2-1.**

A tributary module supporting E3 interfaces is available. The tributary modules do not include the physical connectors and must be used together with suitable connector modules (CM).

CMs are available with support for a different number of interfaces and different types of connectors.

The E3 interfaces provide one service:

- E3 Transparent leased line

E3 transparent leased line

The transparent or unstructured leased line service delivers a full digital bit rate of 34.368 Mbps with no restriction on the binary content.

The service is symmetrical in both directions and supports point-to-point connections only.

An alarm indication signal (AIS) is inserted towards the network if loss of signal (LOS) is detected from the customer.

AIS is also inserted towards the customer if LOS or other major alarms are detected from the networks.

Performance monitoring

AXXMETRO does not support performance monitoring on the E3 ports.

Port states

The E3 interfaces support the following administrative port states:

- In service (IS)
- Out of service (OOS) and this is the default state
- Out of service maintenance (OOS-MT)
- Out of service-Auto in service (OOS-AINS)

The IS state is the normal operation state and in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is enabled
- Loops are not allowed to be activated

The OOS state is equivalent to a port shutdown, in this state the port operates in the following manner:

- The port is not able to carry traffic
- Alarm reporting is disabled for the port

- Loops are not allowed to be activated
- AIS is transmitted

The OOS-MT state is a port state intended for testing, fault finding and maintenance activities, in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are allowed to be activated

The OOS-AINS state is a temporary state intended for provisioning purposes. This means that a port configured to OOS-AINS automatically goes into IS state if a valid signal is applied to the port. A valid signal is a signal that is clearing the LOS (Los of signal) alarm.

For a state change to occur, the signal must be valid for a certain time, which is configurable parameter from 0 to 48 hours in steps of 15 minutes. The parameter is a global parameter for the whole NE.

In this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are not allowed to be activated

Loopbacks

Two types of loopbacks are supported for the interface;

- Line loopback
- Terminal loopback.

The PDH line loopback has the following characteristics:

- The entire PDH E3 signal is looped back
- The loopback is performed after the clock extraction
- AIS is inserted towards the network element itself
- The loopback can only be configured when the port state is OSS-MT

The PDH Terminal loopback has the following characteristics:

- The entire PDH E3 signal is looped back towards the network element itself
- AIS is transmitted towards the line

The loopbacks can only be configured when the port state is OOS-MT.

The loops can be activated from the craft terminal or from the TMN system.

2.4.3 T3 features

General information

AXXMETRO supports a number of T3 interfaces that are mapped into SDH VC-3 containers.

READ MORE: SDH mapping features in "SDH features" on page 2-1.

A tributary module is available supporting T3 interfaces. The tributary modules do not include the physical connectors and must be used together with suitable connector modules (CM).

CMs are available with support for a different number of interfaces and different types of connectors.

The T3 interfaces provide one service as shown below:

- T3 Transparent leased line

T3 transparent leased line

The transparent or unstructured leased line service delivers a full digital bit rate of 44.736 Mbps with no restriction on the binary content.

The service is symmetrical in both directions and supports point-to-point connections only.

An alarm indication signal (AIS) is inserted toward the network if loss of signal (LOS) is detected from the customer.

AIS is also inserted towards the customer if LOS or other major alarms are detected from the networks.

Performance monitoring

AXXMETRO does not support performance monitoring for T3 interfaces.

Port states

The interfaces support the following administrative port states:

- In service (IS)
- Out of service (OOS) and this is the default state
- Out of service maintenance (OOS-MT)
- Out of service-Auto in service (OOS-AINS)

The IS state is the normal operation state and in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is enabled

- Loops are not allowed to be activated

The OOS state is equivalent to a port shutdown, in this state the port operates in the following manner:

- The port is not able to carry traffic
- Alarm reporting is disabled for the port
- Loops are not allowed to be activated
- AIS is transmitted

The OOS-MT state is a port state intended for testing, fault finding and maintenance activities and in this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are allowed to be activated

The OOS-AINS state is a temporary state intended for provisioning purposes. This means that a port configured to OOS-AINS automatically goes into IS state if a valid signal is applied to the port. A valid signal is a signal that is clearing the LOS (Los of signal) alarm.

For a state change to occur, the signal must be valid for a certain time, which is configurable parameter from 0 to 48 hours in steps of 15 minutes. The parameter is a global parameter for the whole NE.

In this state the port operates in the following manner:

- The port is able to carry traffic
- Alarm reporting is disabled
- Loops are not allowed to be activated

Loopbacks

Two types of loopbacks are supported for the interface

- Line loopback
- Terminal loopback.

The PDH line loopback has the following characteristics:

- The entire PDH T3 signal is looped back
- The loopback is performed after the clock extraction
- AIS is inserted towards the network element itself
- The loopback can only be configured when the port state is OSS-MT

The PDH Terminal loopback has the following characteristics:

- The entire PDH T3 signal is looped back towards the network element itself
- AIS is transmitted towards the line

The loopbacks can only be configured when the port state is OOS-MT.

The loops can be activated from the craft terminal or from the TMN system.

2.5 DCN FEATURES

This chapter describes the AXXMETRO with respect to management communication. The first sub-chapter gives an overview of the solution while the following sub-chapters describe the different modes of operation and communication features. The final sub-chapter specifies the formal requirements.

2.5.1 Overview

A management communication network provides communication between the network elements and the management stations thereby enabling a network operator to monitor and control the resources in a network. It is often referred to as DCN (Data Communication Network) or MCN (Management Communication Network). We will use the term DCN. A DCN is usually physically or logically separated from the network carrying customer traffic.

The management of AXXMETRO is based on the IP protocol suite. The main purpose of the DCN is to provide IP-connectivity between a management system and the managed devices in any possible topology and network configuration.

Basically, the IP connectivity is realized through two types of channels:

- Ethernet Channels
- Point To Point (PTP) Channels

This is illustrated by the figure below:

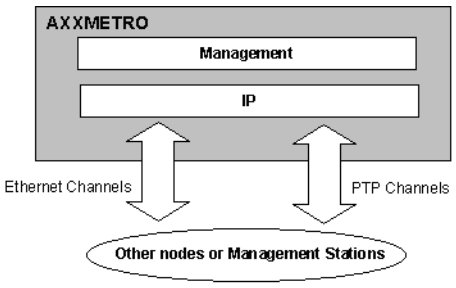


Figure 2-34. DCN channels

The Ethernet Channels in AXXMETRO are:

- External Network, i.e. a dedicated Ethernet port for local and remote access via a separate IP-based network.

- Management VLAN consisting of AXXMETRO LANx and WANx ports.

The PTP Channels in AXXMETRO are:

- SDH-DCC links to neighbour SDH nodes.
- Layer-1 Ethernet Service embedded management communication channel (L1CC)

The AXXMETRO is capable of routing between the different Ethernet and PTP channels. In order to operate in multi-vendor SDH networks, the AXXMETRO provides DCC Cross-Connect (DCCX) functionality in order to "short-cut" DCC channels.

The DCN features of the AXXMETRO are summarised in the DCN protocol reference model below.

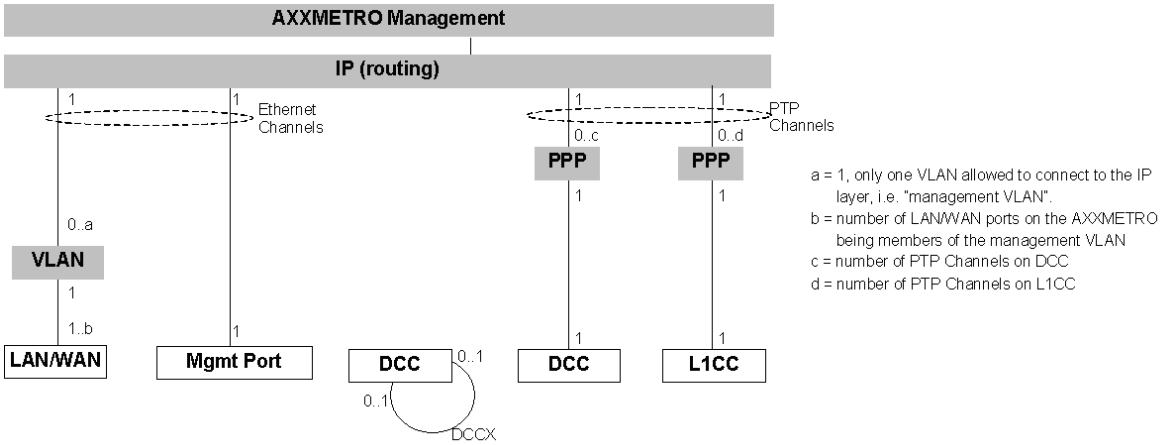


Figure 2-35. DCN protocol reference model

2.5.2 Management Interfaces

The following interfaces are capable of carrying management traffic to/from the AXXMETRO:

- Management port.
  The AXXMETRO has a dedicated Ethernet port for management, here called the "Management Port". This port can be reached via up to four physical connectors. These ports can be used for local management, e.g. connecting a craft terminal, and remote management, e.g. connecting to a separate external management network. It is possible to turn the management port off to avoid unauthorised access.
- LANx ports.
  The LANx ports are Ethernet ports used for connecting customer IP traffic to the AXXMETRO. The LANx ports may be members of the dedicated Management VLAN, which must be assigned to an IP address. A LANx port can carry management traffic to/from the device, provided that it is member of the Management VLAN.
- WAN ports.
  The WANx ports are device internal Ethernet ports that can be mapped into one or more VC-3/4/12 of an SDH STM-n signal. From a DCN perspective, there are no functional differences between LANx and WANx ports. See the LANx port description above.

- L1CC channel.
  The layer-1 Ethernet service (EPL) has an embedded communication channel for management traffic called L1CC. The channel is terminated at the ends of the layer-1 Ethernet service path. The capacity is configurable to 192 kbps or 576 kbps.
- DCC channels.
  The SDH architecture defines data communication channels (DCC) for transport of management traffic in the regenerator section (DCCR - 192 kbps) and in the multiplexer section (DCCM - 576 kbps). A DCC channel supports IP traffic over PPP.

2.5.3 Networking Features

IP Routing

Description

In AXXMETRO the IP routing is for DCN purposes only, and not for customer traffic.

Both static routing and the OSPF routing protocol are supported.

The IP interfaces are either Ethernet or PTP channels.

Both numbered and unnumbered interfaces are supported. The Ethernet interfaces are always numbered. A numbered interface has its own IP address.

The PTP interfaces can be numbered or unnumbered. The IP unnumbered concept allows the system to provide IP processing on a serial interface or in general a point-to-point without assigning it an explicit IP address. The unnumbered interface borrows the IP address of another interface already configured on the system/router (i.e. the Management Port), thereby conserving network and address space, and making the system easier to configure, manage and maintain. The unnumbered mechanism is supported by the OSPF routing protocol.

With IP Unnumbered, all nodes connected via PTP-links may be on the same IP subnet. The IP unnumbered concept is combined with the ARP Proxy mechanism enabling connectivity between the nodes without the need of static routes. The ARP Proxy mechanism uses the routing entries for all the remote PTP nodes, and replies to ARP requests on behalf of them.

Configuration

- Static routes
- Interfaces
- OSPF parameters
- OSPF on/off per interface

Limitations

- Total number of interfaces
- Size of routing tables

DCCX

Description

This feature makes it possible to cross-connect DCC channels without any protocol processing (bit-transparent). The DCCX is hardware-based.Typically, it is used to interconnect two neighbour SDH nodes' DCC channels.

Configuration

- DCC ports subject to cross-connection

Limitations

- Total number of cross-connections

2.5.4 Ethernet Channels

External Network/Management Port

Description

The External Network means that the AXXMETRO can be interconnected with a management station or another network element via a separate network. The physical connection to the AXXMETRO is through one or more of the Management Port connectors.

The direct connection of a craft terminal to the Management Port may be regarded as a special case of the External Network.

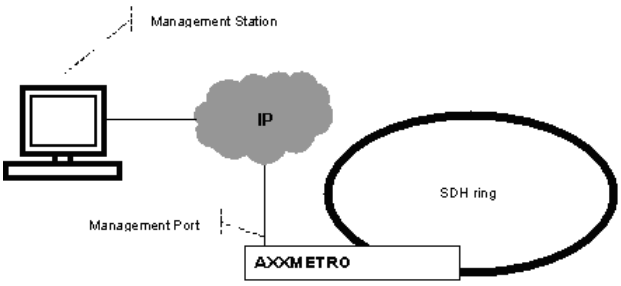


Figure 2-36. External DCN

The IP address of the management port is the identification of the network element from a management point of view. All the unnumbered IP interfaces borrow this IP address. Although the management port may be turned off to prevent unauthorised access, the management port is always available as seen from the IP layer. This way the management address is never "lost".

READ MORE: **"IP Routing" on page 2-62**

Configuration

- mode (IP or off)
- IP Address
- Subnet Mask

Limitations

·The management port cannot be member of a VLAN.

Management VLAN

Description

Management VLAN applies to the AXXMETRO LANx and WANx ports. In AXXMETRO only one VLAN may be connected to the IP layer, i.e. the Management VLAN. This VLAN may be used for carrying management traffic to/from the AXXMETRO.

A LANx or WANx port may be shared between the Management VLAN and a customer VLAN. It is possible to separate the management traffic from the customer traffic by assigning dedicated LAN/WAN ports to management traffic (physical segregation) or by using different VLANs for management and customer traffic (logical segregation).

READ MORE: **LAN and WAN ports are described in "Management Interfaces" on page 2-61**

The Management VLAN is useful in topologies where the SDH-DCC for some reason is not available. This is illustrated in the figure below.

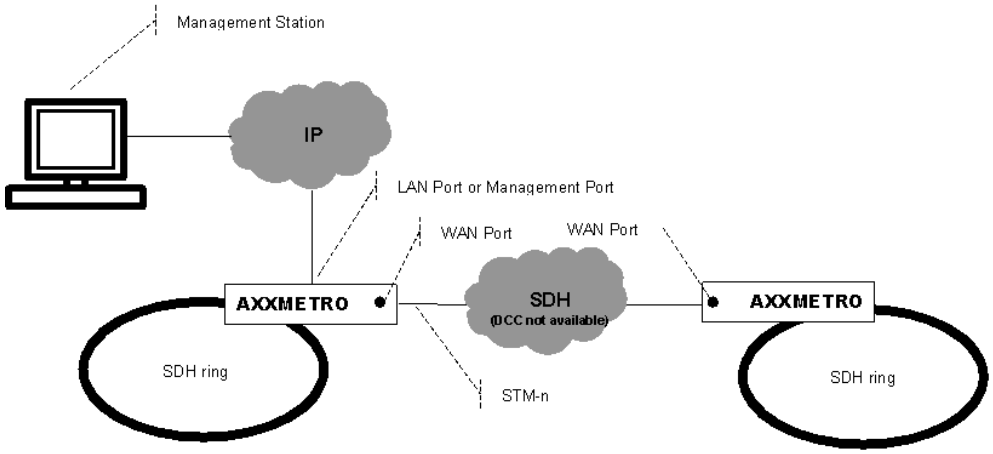


Figure 2-37. Management VLAN application

Between the LANx/WANx ports in a VLAN, the Ethernet switching is always at wire-speed.

READ MORE: **The general Layer-2 switching features of the AXXMETRO in "Ethernet functionality" on page 2-39.**

Configuration

- IP address
- VLAN configuration

Limitations

- Between the Management VLAN and the other PTP or Ethernet channels, the traffic is routed at the IP layer and the routing is carried out in software (by the CPU).
- Only one VLAN allowed to be connected to the IP layer, i.e. the Management VLAN.

2.5.5 PTP Channels

General

The AXXMETRO supports the PPP protocol including RFC 1661 (PPP), RFC 1662 (PPP in HDLC-like framing) and RFC 1332 (IPCP) over the PTP channels.

Each PTP link is connected to the IP layer individually and may run as a numbered or unnumbered interface.

READ MORE: See "Networking Features" on page 2-62 for the description of numbered/unnumbered interfaces.

DCC Links

Description

The IP-based management traffic is carried in PPP over the SDH DCC channels according to the NSIF-DN-0101-001 standard. This feature is typically used for communicating between two neighbour SDH nodes both supporting this mode. There is one PPP link per DCC channel. Both IP numbered and unnumbered are supported on the DCC Links.

A typical application of the PPP on DCC link is shown in the figure below.

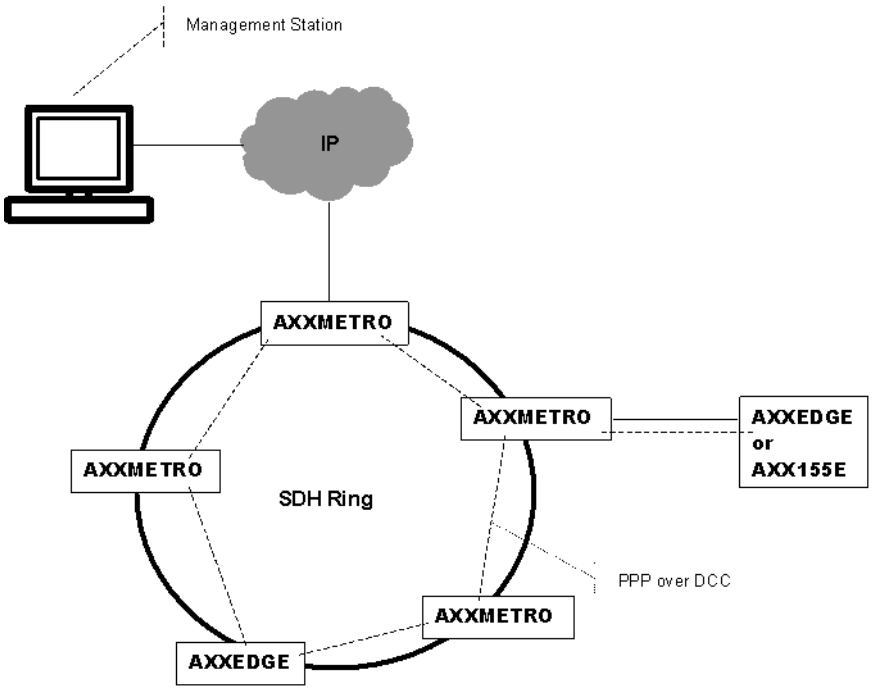


Figure 2-38. PPP on DCC Links

Configuration

- Select DCC port
- CRC, 16 bits or 32 bits (per DCC)
- IP address (numbered interface only)

Limitations

- Maximum number of active DCC/L1CC channels in use is 48 (32 DCC-R and 16 DCC-M). For one SDH-port, both DCC channels may be active simultaneously.

L1CC Links

Description

The IP-based management traffic is carried in PPP over the L1CC port. The L1CC mechanism applies to the Layer-1 customer Ethernet service, i.e. the Ethernet Private Line (EPL) where the management traffic is carried in a separate logical channel within the SDH payload allocated to the EPL. The L1CC channel is useful in topologies where (parts of) the SDH-DCC for some reason is not available. This is illustrated in the figure below.

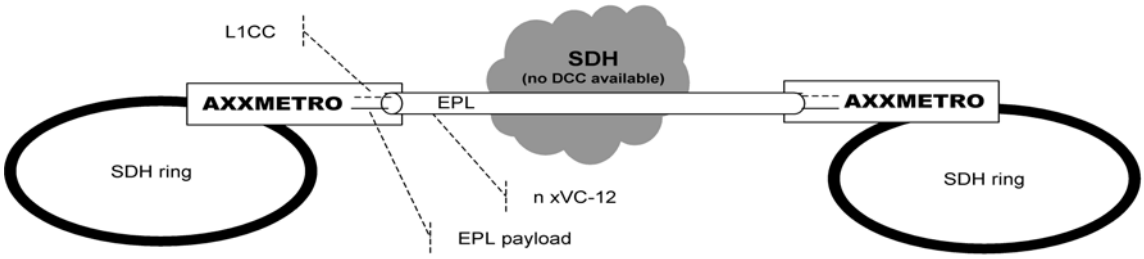


Figure 2-39. L1CC application

READ MORE: **“Ethernet Private Line” on page 2-34**

Configuration

- Select L1CC port.
- Speed, 192 kbps or 576 kbps (per L1CC port).

Limitations

- Only IP unnumbered is supported on the L1CC Links.
- Maximum number of active DCC/L1CC channels in use is 48 (32x192 kbps DCC/L1CC and 16x576kbps DCC/L1CC).

2.5.6 Security

In this context the term security encompasses the confidentiality and integrity of the management information flowing through the DCN.

To secure the confidentiality and integrity of the management information, the use of encryption mechanisms is recommended. However, this is not regarded as a DCN issue. The DCN is just a networking mechanism. Encryption is up to the application level to decide.

The Management Port can be turned on and off, thereby preventing unauthorized access to the management network.

The highest risk area for DCN is the Management VLAN. Although the AXXMETRO keeps the customer Ethernet traffic at the layer 1 or 2, and never brings the customer Ethernet traffic up to the routing layer, this may happen in other devices throughout the network giving customers access to the AXXMETRO management layer. No mechanisms are built in to prevent this type of configuration flaws.

Although customer traffic is separated from management traffic, the following mechanisms are employed to prevent customers from interfering with DCN traffic (applicable to the Management VLAN only):

- VLAN hopping prevention - preventing a customer form using another VLAN tag.

2.5.7 High Availability

In general, the availability and connectivity of the DCN is a network design issue, especially with respect to redundancy and single point of failure. The automatic routing protocols on the IP (OPSF) and the Rapid Spanning Tree mechanism are able to recover from topology changes in seconds.

As described earlier, the AXXMETRO supports three different SDH protection schemes:

- 1:1 Equipment protection,
- MSP (1+1 link protection)
- SNCP (inherent or non-intrusive path protection)

The in-band management modes (Management VLAN and L1CC) experience the same protection as the user traffic. If the Management VLAN or L1CC channels are used on a protected module (Equipment protection), link (MSP), or path (SNCP), the switchover is transparent to the DCN higher levels.

The out-of-band management modes (IP over DCC and DCC cross connection DCCX) are independent of SNCP. In addition DCCX is independent of both MSP and equipment protection.

For IP over DCC (numbered or unnumbered) running over MSP protected links, the management traffic follows the user traffic, i.e. management traffic is sent over both links (working and protecting), but received only from the active link.

For IP over DCC (numbered or unnumbered) running over equipment-protected modules, the management traffic is sent to both working and protecting modules, but received only from the active module.

2.5.8 Compatibility Issues

The main changes to DCN introduced in AXXMETRO are:

- OSI is not supported in AXXMETRO R1. A new OSI tunneling mechanism enabling unnumbered point-to-point tunnels over OSI based networks will be available in a future release.
- "IP/DCC & Routing" or "IP/DCC & Broadcast" are not supported.

The AXXMETRO backward compatibility with the other AXXESSIT products is described in the table below.

Connectivity/Feature	AXX155	AXX155E	AXXEDGE (1)	AXXCONNECT	AXXMETRO
Ethernet on Management port	x	x	x	x	x
OSI on management port	x	x	x	x	(F)
IP routing (DCN)		x	x	x	x
Management VLAN	x (4)	x	x (2)	x(2)	x (2)
IP over OSI	x	x	x	x	(F)
PPP on DCC link (numbered)	(F)	x	x	x	x
PPP on DCC link (unnumbered)		R3	R2	x	x
PPP on L1CC link			R2 (3)	x(3)	x
IP/DCC broadcast	x	x			
IP/DCC routing		x	x	x	

Table 2.6. AXXMETRO compatibility with other AXXESSIT products

(1) - AXX155A is regarded as a variant of the AXXEDGE. AXX10 regarded part of AXXEDGE.

(2) - If equipped with a LANx/WANx port.

(3) - If equipped with a LAN port in L1 mode.

(4) - Via external cable

(F) - Future

All AXXESSIT network elements may interwork using:

- External Network (management port)
- PPP Channel on DCC Link.
- The Management VLAN can be used to interconnect the AXXMETRO and all other AXXESSIT products.

2.6 REDUNDANCY AND RELIABILITY

2.6.1 System availability

AXXMETRO is designed for use in a Carrier Class environment supporting high availability of services. This is done be using redundant modules for all critical systems and also design for a maximum MTBF for all modules.

The availability of a service can be calculated with the following formula:

A=MTBF/(MTBF+MTTR)

MTBF is the Mean Time Between Failures

MTTF is the Mean Time To Repair

It is possible to deliver a service with an availability of 99.99% with a single aggregate module and 99.999% with a duplicated aggregate module.

The AXXMETRO must be equipped with redundant modules to be available to meet the availability requirements of 99.999%. This requires that the maximum downtime in a year is appr. 5 minutes.

It is also possible to meet the availability requirements of 99.99% with a single AM. This requires that the maximum downtime in a year is appr. 53 minutes. The single AM is a single point of failure and the MTTR must be short enough to be able to meet the availability requirements with a single AM.

The availability requirements discussed above puts a number of requirements on the hardware and the software as described in the following chapters.

2.6.2 Hardware requirements

Equipment protection

1:1 Equipment protection is supported for both tributary modules and aggregate modules.

The system controller, TDM matrix and the Ethernet crossbar are protected on the aggregate modules but the optical interfaces are not protected.

NOTE! **The optical interfaces are not protected by equipment protection. MSP, SNCP, LCAS or RSTP using ports on two different modules obtain protection against equipment failures for the optical interfaces.**

The electrical tributary modules are protected with the help of the connector modules. The physical electrical interfaces are mounted on the connector modules. The protection switching is also performed in the connector modules.

This is currently supported for E1, E3 and T3 STM-1e interfaces. The electrical interfaces for FE and GE are not protected with equipment protection and must be protected in the same way as for the optical tributary modules.

The modules that protect each other are located side by side. Slot 1 is protected by slot 2, slot 3 by slot 4, slot 5 by slot 6, slot 7 by slot 8 and slot 9 by slot 10.

The protection switching is controlled from the active aggregate module.

Back plane details

The back plane is a single point of failure since it is not redundant. Therefore it is very important to have the highest possible MTBF value. No single point of failures shall affect the ability to deliver a service.

Redundant point-to-point connections are used in the back plane if possible. A failed tributary module or aggregate module is not able to disturb other modules in the system.

Redundant bus structures can also be used as long as a failure of one bus cannot affect the redundant bus.

A non-redundant bus structure can be used as long as it is possible to survive a single stuck-at error. It is possible to physically disconnect a failed module from the bus if a bus error is detected.

It is not allowed to mount any active components or passive components like resistors and capacitors. Note that the inventory EEPROM and bus-termination resistors are allowed on a small module in the back plane. It is possible to replace this module if it is faulty or if an upgrade the information in the inventory EEPROM is needed.

It is possible to repair bent or broken connector pins in the field.

Module details

The modules have their own power supply that is fed from two independent power supply sources. The power sources are connected together with wire-or diodes in the modules. Every module that is connected to the -48V power has an internal fuse to protect the external power sources against internal power failures.

The internal power supply in a module generates a number of different voltages. The modules include a monitoring device for the power supply that generates an alarm if any of the internal voltages are outside the specification.

It is possible to disable the power supply in a tributary module. This is controlled from the active aggregate module.

The modules communicate through a back plane processor bus that is connected to all aggregate and tributary modules. The active aggregate module can disable the back plane processor bus interface on failed module to prevent stuck-at errors on that bus.

The aggregate and tributary modules perform a self-test at power up. If the module detects an error it reports this to the active aggregate module.

The fan module has two internal power supplies and they are both fed from two independent external power supply sources. The power sources are connected together with wire-or diodes in the modules. Both power supplies have an internal fuse to protect the external power sources against internal power failures.

The fan module includes six independent fans. They are all powered from both power supplies. The fan module monitors the fans and reports failures to the aggregate modules.

2.6.3 Software requirements

The equipment redundancy capabilities provided by hardware is controlled by software in order to be able to protect service. The SW is able to detect traffic affecting hardware errors and switch-in redundant modules. But the system also survives failure of the microprocessor system itself, i.e. both hardware and software errors. Thus the system software, i.e. the two processor systems together, is fault-tolerant both with respect to hardware and software errors. Software on both aggregate modules therefore continuously monitors their own and each others operation. If STANDBY detects that the ACTIVE no longer behaves normally, it performs a take-over. But the criteria for doing so are very strict.

SW error prevention

Software errors are by nature different from component errors. SW does not fail due to "wear-out" etc, but is the result of a design error. Therefore, redundancy does not necessarily protect against SW errors. It is therefore important to take steps to avoid making SW errors.

Compliance is not required for open-source software or for software re-used from other AXXESSIT products, e.g. AXXEDGE. In these cases, low error occurrence is assumed from extensive reviews and/or long-term field use.

Code reviews are conducted for all SW components classified as critical to availability.

SW error detection, damage prevention and recovery actions

In practice, it is impossible to guarantee that all errors are removed before the software is shipped. Mechanisms are therefore implemented that:

- Detect if errors occur
- Limits the damage caused by the error
- Apply actions to recover from the error

A heartbeat mechanism is implemented in order to detect hung or killed processes. The heartbeat process itself is supervised by a watch-dog (WD).

A two-step watchdog is used. When it expires the first time, a non-maskable interrupt is generated. If the SW responds to this interrupt, important debug and log-information are saved.

If the SW does not respond to this interrupt, the second WD timeout cause a reboot.

All processor exceptions that occur are handled in order to detect possible error situations.

Special attention is given to driver code that runs in kernel space, since an error in this case may impact the whole software system.

The processor's memory-management unit (MMU) is used to physically prevent e.g. a stray pointer or invalid array index in one module from overwriting data in another module.

It is possible to restart individual sub-systems in order to reduce the impact of an error on the system.

If it is not possible to recover from the error on the current ACTIVE aggregate module, a switchover is performed.

Error logs

Errors that occur are logged in order to:

a) Provide statistical information for HW and SW error occurrence and availability impact

b) Provide debugging information in order to be able to eliminate defects as quick as possible

Three logs are implemented:

- A HA-log for errors/events that may impact traffic availability. This log survives a power-down. It is also synchronized between the aggregate modules in order to survive a switchover.
- An Error-log for all critical/major errors and events. This log is stored in volatile RAM, and is not synchronized between the aggregate modules. The 10 most recent entries are stored in the HA-log.
- Error-counters for all errors including those with severity Minor and Warning.

Redundancy configuration

The system runs in redundant mode whenever there are two aggregate modules present that satisfy the criteria for redundant operation. In redundant operation the two-processor systems operate as ACTIVE and WARM STANDBY. A definition of the different standby modes is describes below:

- COLD STANDBY
  The standby module is inactive until it becomes active. A full initialisation is necessary before it can become active, and the switchover time is therefore longer than for "warm standby". Neither the configuration database nor any dynamic data are synchronized. This configuration is used if two aggregate modules with different software releases are equipped.
- WARM STANDBY
  The standby module runs in a standby, partly initialised state where it maintains its configuration database synchronized with the active module. Dynamic data for selected applications are also synchronized (checkpointed). It can therefore become active in less time and with less interruption than the cold standby. This configuration is used when AXXMETRO operates in redundant mode.

Configuration data is copied from the ACTIVE to the STANDBY base when a change occurs.

Dynamic data needed for traffic preservation are periodically transferred between the two controllers, e.g. some SNCP, MSP and EPS data. Dynamic data not important for traffic preservation (e.g. performance data), is not synchronized in R1.0. When a switchover occurs, the new ACTIVE can start from a partial initialised i.e. "warm" state.

When the two aggregate modules run different network releases, they do not operate in redundant mode, but in a mode called "Duplex". That means that the CDBs are not synchronised and that checkpointing of dynamic data is not performed.

Since the CDBs are not synchronised, a switch-over could result in a totally different situation. Therefore, NO automatic switch-over is performed in this operating mode.

In order to make the system redundant, the easiest way is to start the Maintenenace Wizard and issue the "Align NR" command. This command copies the Network Release from the active module to the standby, and restarts it. The system will then enter redundant mode automatically, and also copy the CDB from the active to the standby (which now becomes warm standby).

SW/FW upgrade

Redundancy is utilized during SW/FW upgrades to reduce traffic impact by using a rolling upgrade.

I.e. when new SW/FW is downloaded, the following steps are performed:

1. Download the new SW to the ACTIVE aggregate module
2. Copy it to the STANDBY module
3. Restart the STANDBY module in order to activate the new SW
4. Perform a switch-over
5. Restart the previous ACTIVE with the new SW
6. Upgrade FW on tributary modules if required, also in a rolling fashion

Aggregate module switchover

The switchover from one aggregate module to the other aggregate module is not affecting TDM traffic and L1 Ethernet traffic, but it will affect Ethernet traffic running L2 mode. The Ethernet crossbar and the distributed Ethernet switches are reset when the switchover is performed and the MAC tables are cleared.

Note that the traffic interfaces on the aggregate modules are available for traffic on both the active and the standby aggregate module. The work in similar manner as the traffic interfaces on the tributary modules.

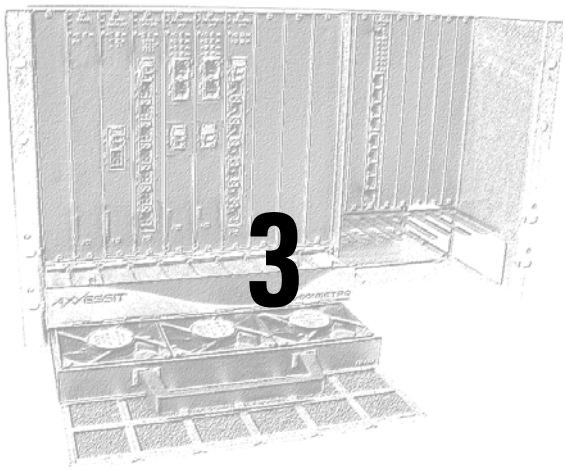
Failure rates

The MTBF values are calculated according to Bellcore specification SR-233. The calculation is based on a ground benign environment and a temperature of 40°C. The interface modules are not included in the calculation for the relevant modules.

Module	Calculated (Years)
Basic shelf	81,1
Backplane	150,9
MM	193,0
IM	1934,8
AM-2xSTM1/4-SFP	42,0
AM-1xSTM16-SFP	42,9
TM-1xSTM16-SFP	96,4
TM-4xSTM4/1xSTM16-SFP	81,5
TM-4xSTM1/1xSTM4-SFP	90,0
TM-8xSTM1-SFP	82,9
TM-6xE3/T3	82,8
TM-63xE1	64,6
TM-8xE1	94,1
TM-8xFE-16xMAP-SFP	48,8
TM-2xGE-2xMAP-SFP	55,8
MM	232,7
CM-8xE1-RJ45	711,2
CM-8xFE-RJ45	484,7
CM-PROT-8xFE-RJ45	247,4

Module	Calculated (Years)
CM-PROT-8xFE-RJ45_TO	505,1
CM-PROT-8xFE-RJ45_BO	484,7
CM-6x1.0/2.3	634,2
CM-PROT-6x1.0/2.3	252,6
CM-PROT-6x1.0/2.3_BO	262,7
CM-PROT-B-6x1.0/2.3_TO	6523,2
CM-PROT-4xSTM1E	258,0
CM-PROT-4xSTM1E_BO	268,6
CM-PROT B-6x1.0/2.3_TO	6523,2
CM-2xLFH	199,6
FM PBA	50,3
IM	1934,8
BACKPLANE	150,9

Table 2.7. MTBF values for shelf and modules



3 AGGREGATE MODULES, MISC.MODULE AND FAN MODULE

3.1 INTRODUCTION

This chapter presents the Aggregate Modules (AM), the Miscellaneous Module (MM) and the Fan Module (FM)

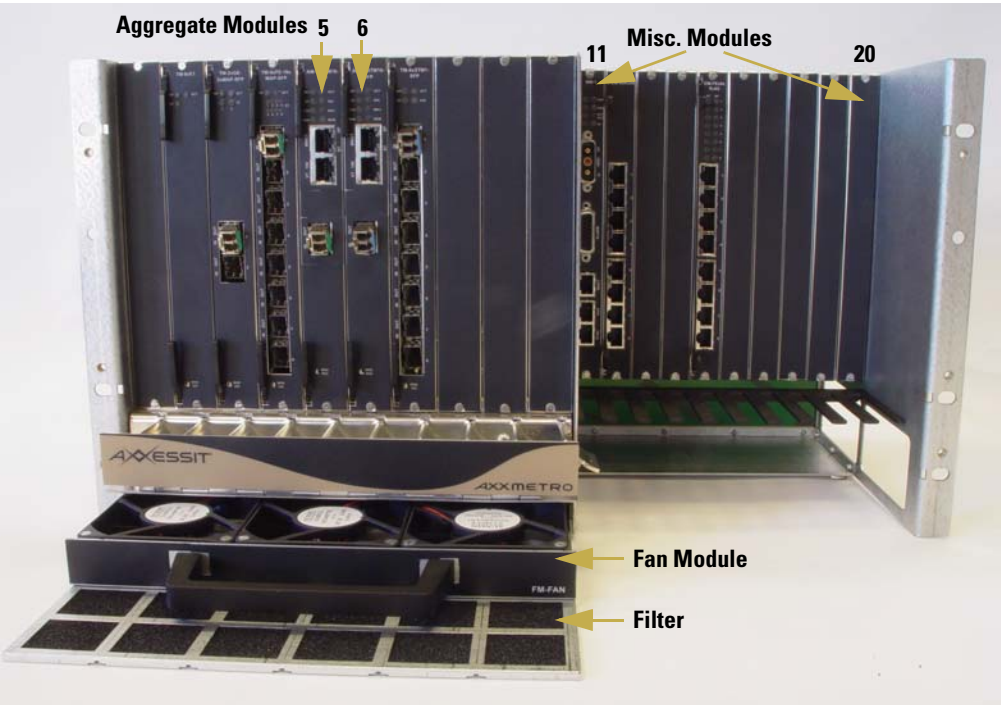


Figure 3-1. AXXMETRO overview

The AXXMETRO must have at least one AM and one MM to work properly. For redundancy, one additional AM will protect the system. If only one AM, placed in slot 5, the MM must be placed in slot 11. If AM placed in slot 6, the MM must be placed in slot 20

Available AMs:

·AM-1xSTM16-SFP - (1xSTM-16 optical interface)

·AM-2xSTM1/4-SFP - (2xSTM-1 optical interface or 2xSTM-4 optical interface)

Available MM:

MM-1

Even if one MM can serve two AMs, we recommend that each AM has its own MM to achieve the best availability.

Available FM:

FM-FAN

This is a fan module that supports 6 fans. It includes fan alarm monitoring circuits for all fans

3.2 AM-2XSTM1/4-SFP

3.2.1 Overview

This is an aggregate module that supports two STM-1 or two STM-4 interfaces. It is optimised for low cost since it is going to be used in low capacity SDH networks.

It offers the following functionality:

- System controller
- Local interfaces
- TDM cross connect
- Ethernet crossbar
- SDH features
- SETS functionality
- Traffic interfaces (2 x SFP)
- Redundancy
- LED indicators
- Inventory EEPROM
- Local power supply

It must be used together with one or two miscellaneous modules (MM-1). The MM contains the following additional interfaces for the aggregate module:

- Power interface
- Management interface
- Synchronisation interface
- Auxiliary interface
- Alarm interface

3.2.2 Features

System controller

The system controller consists of a processor that includes the following features:

- Ethernet interface used by the craft terminal
- Multiple HDLC controllers that is used for DCC traffic and intercommunication between two aggregate modules
- The system controller has a DCC processor that is capable of processing up to 256x64 kbps channels
- PCI interface for connection to the Ethernet crossbar
- UART for the CLI interface
- I2C interface for RTC

A boot FLASH contains the boot software. A 1GB Compact FLASH card stores two banks of software.

The software is executed from a 256MB SDRAM.

It is also possible to mount 256MB or 512MB of SDRAM in a proprietary daughter card.

An EEPROM stores inventory data for the aggregate module.

Local interfaces

The aggregate module has two local interfaces:

- A CLI serial interface as described in chapter 7.31.
- A local craft terminal Ethernet interface as described in chapter 7.14

TDM cross connect

The aggregate module has non-blocking SDH cross-connect with a higher order capacity of 256x256 STM-1 equivalents (including the interfaces towards the lower order matrix) and a lower order capacity of 96x96 STM-1 equivalents.

The higher order matrix switches VC-4 virtual containers and the lower order matrix switches VC-12 and VC-3 virtual containers.

The cross-connect supports uni-directional and bi-directional connections at all layers.

The cross-connect is connected to all eight tributary modules, the neighbour aggregate module and the two onboard optical interfaces.

The interface towards the tributary modules use high speed SERDES with a capacity equivalent to an STM-16. The interface towards the aggregate card also has the same capacity.

Ethernet crossbar

The aggregate module includes an Ethernet crossbar for interconnection between the different tributary modules. The tributary modules that include L2 Ethernet functionality have an internal

Ethernet switch. The crossbar interconnects the internal Ethernet switches to make them look like one big Ethernet switch.

The crossbar has eight ports and a raw switching capacity of 23 Gbps. The total data capacity is eight full duplex gigabit Ethernet ports (16 Gbps).

The crossbar is only connected to slot 3, 4, 9 and 10 positions. The other slots are not connected to the crossbar. Ethernet modules with L2 functionality must be inserted in the slots with connection to the crossbar, but it is possible to use Ethernet modules with L1 functionality in the other positions.

The processor is directly interconnected to the crossbar via a PCI interface. All communication between the processor and the Ethernet switches uses this interface.

Eight high speed SERDESes are used as a back plane interface for the crossbar ports.

SDH features

The aggregate module includes the following SDH functionality:

- STM-1/4 line interfaces
- HO cross connect, equal to 256x256 AU-4/VC-4 equivalents
- LO cross connect, equal to 96x96 VC-4 equivalents
- SETS functionality

SETS functionality

The aggregate module includes a full SETS implementation. It has an internal stable local oscillator which is connected to all tributary modules and it is possible to connect it to synchronisation sources on all modules.

A synchronisation interface is connected to the physical synchronisation interface on both miscellaneous modules.

An auxiliary interface provides access to selected overhead channels in the SDH frames. The physical interface is connected to the physical auxiliary interface on both miscellaneous modules.

Traffic interfaces

The two traffic interfaces include full SDH processing before the traffic is connected to the cross-connect.

The traffic interfaces are based on the SFP multi source agreement (MSA). The modules support hot insertion and it is possible to add the interface modules in the field.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) will be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets its specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

The traffic interface can be configured for STM-1 or STM-4 line rates. Note that both interfaces run at the same speed. It is not possible to have one running at STM-1 and the other running at STM-4 except during upgrade of interfaces from STM-1 to STM-4.

The following modules are supported:

- S-1.1 Short haul STM-1
- L-1.1 Medium haul STM-1
- L-1.2 Long haul STM-1
- "L-1.2C" CWDM STM-1 (eight wavelengths)
- STM-1e electrical STM-1 (G.703)
- S-4.1 Short haul STM-4
- L-4.1 Medium haul STM-4
- L-4.2 Long haul STM-4
- "L-4.2C" CWDM STM-4 (eight wavelengths)

The optical interfaces are tilted downwards with an angle of 22.5 degrees.

Interfaces on MM

The AM connects to the interfaces on the two miscellaneous modules. Each miscellaneous module has a power interface, a management interface, a synchronisation interface, an auxiliary interface and an alarm interface.

The power interfaces are connected to both AMs and are completely independent.

The management interfaces are connected to both AMs, but only the active AM controls the interfaces. The two management interfaces are redundant and the active AM will only use one of them.

The synchronisation interfaces are connected to both AMs, but only the active AM controls the interfaces. The synchronisation inputs are completely independent. The synchronisation outputs are controlled from the same T4 synchronisation process.

The auxiliary interfaces are connected to both AMs, but only the active AM controls the interfaces. The auxiliary interfaces are completely independent.

The alarm interfaces are connected to both AMs, but only the active AM controls the interfaces. The alarm inputs are completely independent. The alarm outputs present the same alarm status on both interfaces.

Redundancy

Redundant operation is characterized by one module operating as Active and the other as Warm Standby. As long as there is at least one module installed, there is only one Active module. There can be temporary exceptions from this rule, e.g. both may be Cold Standby during start-up. But in order to enter redundant operation, there must also be one module operating as Hot Standby.

The following conditions must be fulfilled before redundant operation can be achieved:

- Both AMs must be in identical ModuleModes
- Both AMs must run identical SW releases

TIP **A mode defines a set of characteristics for the module. Different module hardware types can operate in the same mode. The characteristics can reflect a specific port configuration or a specific set of functions.**

The secondary AM will have hot standby mode and switch to active mode and handle all the functionality if the primary AM fails or is removed.

LED indicators

Visual indicators (LEDs) provide the status of the AXXMETRO and the module itself. The LEDs are placed on the front of the aggregate module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red
CRI	Red	One or multiple critical alarms are active when the LED is Red
MAJ	Red	One or multiple major alarms are active when the LED is Red
MIN	Yellow	One or multiple minor alarms are active when the LED is Yellow
ACT	Green/Yellow	The module is in active state when the LED is Green. The module is in standby state when the LED is Yellow.
SF	Yellow	One of the provisioned optical or electrical interfaces has an active alarm when the LED is Yellow
SIG	Green/Yellow	An optical signal is present on a provisioned or un-provisioned optical interface when the LED is Green. An optical signal is not present on a provisioned interface when the LED is Yellow. If no signals are present and the optical interfaces are not provisioned the LED is extinguished. Note that one LED is used for both optical interfaces.
REM	Red	A critical, major or minor alarm is active in the remote end when the LED is red
ST	Green	This LED applies only for the local craft terminal interfaces on the module. The link is down if the LED is extinguished. The link is up if the LED is green. The link is up and receiving or transmitting traffic when the LED is blinking green
SP	Yellow/Green	This LED applies only for the local craft terminal interfaces on the module The link speed is 10 Mbps when the LED is yellow The link speed is 100 Mbps when the LED is green The link speed is 1000 Mbps when the LED is extinguished

Table 3.1. LED functionality on AM-2xSTM1/4-SFP

All LEDs for the optical interfaces operate independently from the ACT status of the module.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. To change the fuse, the aggregate module must be removed from the AXXMETRO shelf.

A number of low voltage power supplies convert the +3.3V to the other voltages needed in the module.

- The +3.3V is also used to power the auxiliary circuits on all modules in the AXXMETRO (e.g. inventory EEPROMs). This power supply is called the auxiliary power supply. An electronic fuse protects the output voltage to the auxiliary circuits.

Power Consumption

54W

Self test

The module performs a self test procedure at power up and reports failures to the active aggregate module.

3.3 AM-1XSTM16-SFP

3.3.1 Overview

This is an aggregate module that supports one STM-16 interface.

It offers the following functionality:

- System controller
- Local interfaces
- TDM cross connect
- Ethernet crossbar
- SDH features
- SETS functionality
- Traffic interface (1x SFP)
- LED indicators
- Inventory EEPROM
- Local power supply

It must be used together with one or two miscellaneous modules (MM-1). The MM contains the following additional interfaces for the aggregate module:

- Power interface
- Management interface
- Synchronisation interface
- Auxiliary interface
- Alarm interface

3.3.2 Features

System controller

The system controller consists of a processor that includes the following features:

- Ethernet interface used by the craft terminal
- Multiple HDLC controllers that is used for DCC traffic and intercommunication between two aggregate modules
- PCI interface for connection to the Ethernet crossbar
- UART for the CLI interface
- I2C interface for RTC

A boot FLASH contains the boot software. A 1GB Compact FLASH card stores two banks of software.

The software is executed from a 256MB SDRAM.

It is also possible to mount 256MB or 512MB of SDRAM in a proprietary daughter card.

An EEPROM is included to store inventory data for the aggregate module.

Local interfaces

The aggregate module has three local interfaces:

- A CLI serial interface as described in chapter 7.31.
- A local craft terminal Ethernet interface as described in chapter 7.14
- 16 DCCM and 32DCCR

TDM cross connect

The aggregate module has non-blocking SDH cross-connect with a higher order capacity of 256x256 STM-1 equivalents (including the interfaces towards the lower order matrix) and a lower order capacity of 96x96 STM-1 equivalents. The higher order capacity is 160x160 STM-1 equivalents if the lower order interfaces are not included.

The higher order matrix switches VC-4 virtual containers and the lower order matrix switches VC-12 and VC-3 virtual containers.The cross-connect supports uni-directional and bi-directional connections at all layers.

The cross-connect is connected to all eight tributary modules, the neighbour aggregate module and an onboard optical interface.The interface towards the tributary modules use high speed SERDES with a capacity equivalent of STM-16. The interface towards the aggregate card also has the same capacity.

Ethernet crossbar

The aggregate module includes an Ethernet crossbar for interconnection between the different tributary modules. The tributary modules that include L2 Ethernet functionality have an internal Ethernet switch. The crossbar interconnects the internal Ethernet switches to make them look like one big Ethernet switch.

The crossbar has eight ports and a raw switching capacity of 23 Gbps. The total data capacity is 8 full duplex gigabit Ethernet ports (16 Gbps).

The crossbar is only connected to slot 3, 4, 9 and 10 positions. The other slots are not connected to the crossbar. Ethernet modules with L2 functionality must be inserted in the slots with connection to the crossbar, but it is possible to use Ethernet modules with L1 functionality in the other positions.

The processor is directly interconnected to the crossbar via a PCI interface. All communication between the processor and the Ethernet switches uses this interface.

Eight high speed SERDESes are used as a back plane interface for the crossbar ports.

SDH features

The aggregate module includes the following SDH functionality:

- STM-16 line interface

- HO cross connect, equal to 256x256 AU-4/VC-4 equivalents
- LO cross connect, equal to 96x96 VC-4 equivalents
- SETS functionality

SETS functionality

The aggregate module includes a full SETS implementation. It has an internal stable local oscillator that is connected to all tributary modules and it is possible to connect it to synchronisation sources on all modules.

There is a synchronisation interface that is connected to the physical synchronisation interface on both miscellaneous modules.

The module includes an auxiliary interface that provides access to selected overhead channels in the SDH frames. The physical interface is connected to the physical auxiliary interface on both miscellaneous modules.

Traffic interface

The traffic interface includes full SDH processing before the traffic is connected to the cross-connect.

They are based on the SFP multi source agreement (MSA) and it is possible to add the interface modules in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all. The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) will be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets all specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

The traffic interface can be configured for STM-16 line rates.

The following modules are supported:

- S-16.1 Short haul STM-16
- L-16.1 Medium haul STM-16
- L-16.2 Long haul STM-16
- "L-16.2C" CWDM STM-16 (8 wavelengths)

The optical interfaces are tilted downwards with an angle of 22.5 degrees.

Interfaces on MM

The AM connects to the interfaces on the two miscellaneous modules. Each miscellaneous module has a power interface, a management interface, a synchronisation interface, an auxiliary interface and an alarm interface.

The power interfaces are connected to both AMs and are completely independent.

The management interfaces are connected to both AMs, but only the active AM controls the interfaces. The two management interfaces are redundant and the active AM will only use one of them.

The synchronisation interfaces are connected to both AMs, but only the active AM controls the interfaces. The synchronisation inputs are completely independent. The synchronisation outputs are controlled from the same T4 synchronisation process.

The auxiliary interfaces are connected to both AMs, but only the active AM controls the interfaces. The auxiliary interfaces are completely independent.

The alarm interfaces are connected to both AMs, but only the active AM controls the interfaces. The alarm inputs are completely independent. The alarm outputs present the same alarm status on both interfaces.

Redundancy

Redundant operation is characterized by one module operating as Active and the other as Warm Standby. As long as there is at least one module installed, there is only one Active module. There can be temporary exceptions from this rule, e.g. both may be Cold Standby during start-up. But in order to enter redundant operation, there must also be one module operating as Hot Standby.

The following conditions must be fulfilled before redundant operation can be achieved:

- Both AMs must be in identical ModuleModes
- Both AMs must run identical SW releases

A mode defines a set of characteristics for the module. Different module hardware types can operate in the same mode. The characteristics can reflect a specific port configuration or a specific set of functions.

The secondary AM will have hot standby mode and switch to active mode and handle all the functionality if the primary AM fails or is removed.

LED indicators

Visual indicators (LEDs) provide the status of the AXXMETRO and the module itself. The LEDs are placed on the front of the aggregate module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red
CRI	Red	One or multiple critical alarms are active when the LED is Red
MAJ	Red	One or multiple major alarms are active when the LED is Red
MIN	Yellow	One or multiple minor alarms are active when the LED is Yellow
ACT	Green/Yellow	The module is in active state when the LED is Green. The module is in standby state when the LED is Yellow.
SF	Yellow	One of the provisioned optical or electrical interfaces has an active alarm when the LED is Yellow

LED name	Colour	Functionality
SIG	Green/Yellow	An optical signal is present on a provisioned or un-provisioned optical interface when the LED is Green. An optical signal is not present on a provisioned interface when the LED is Yellow. If no signals are present and the optical interfaces are not provisioned the LED is extinguished. Note that one LED is used for both optical interfaces.
REM	Red	A critical, major or minor alarm is active in the remote end when the LED is red
ST	Green	This LED applies only for the local craft terminal interfaces on the module. The link is down if the LED is extinguished. The link is up if the LED is green. The link is up and receiving or transmitting traffic when the LED is blinking green.
SP	Yellow/Green	This LED applies only for the local craft terminal interfaces on the module The link speed is 10 Mbps when the LED is yellow The link speed is 100 Mbps when the LED is green The link speed is 1000 Mbps when the LED is extinguished

Table 3.2. LED functionality on AM-1xSTM16-SFP

All LEDs for the optical interfaces operate independently from the ACT status of the module.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The aggregate module must be removed from the AXXMETRO shelf to change the fuse. A number of low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The +3.3V is also used to power the auxiliary circuits on all modules in the AXXMETRO (e.g. inventory EEPROMs). This power supply is called the auxiliary power supply. An electronic fuse protects the output voltage to the auxiliary circuits.

Power Consumption

54W

Self test

The module performs a self test procedure at power up and reports failures to the active aggregate module.

3.4 MM-1

3.4.1 Overview

This is a miscellaneous module that must be used together with the aggregate modules.

NOTE! **One MM can support two AMs, but this is not recommended for availability considerations.**

It offers the following functionality:

- Power interface
- Synchronisation interface
- Auxiliary interface
- Management interface
- Alarm interfaces
- LED indicators
- Inventory EEPROM

3.4.2 Features

Power interfaces

The module has a power interface that includes a fuse to protect the external power source against internal failures.

READ MORE: **“POWER” on page 7-53**

Over voltage protection and EMC filter are included in the module.

The AXXMETRO is designed to operate from a DC power source with a nominal voltage of -48V or -60V power source complying with EN/ETS 300132-2. It has a power supervision circuit that monitors the input voltage and indicates if the voltage is outside the working range.

With the battery alarm switch on the MM-1 module in the -48V position a battery power Low/High alarm will arise when the input voltage is below -40V or above -57V. With the battery alarm switch on the MM-1 module in the -60V position a battery power Low / High alarm will arise when the input voltage is below -50V or above -72V. The AXXMETRO will continue to function until the input voltage drops below -37,5V or rise above -72,5V, where power to all modules will be shut down.

NOTE! **It is also possible to set the mode with a internal switch in the module. This switch can be overridden from the I2C bus.**

The mode of operation is set from the I2C bus and the power alarm status is also read from the I2C bus.The power interface from the miscellaneous modules is independently connected to all aggregate modules, tributary modules and the fan module.

Power Consumption

1W

Synchronisation interface

The module has the physical interface and connector for the 2 MHz/2 Mbps synchronisation interface. It is directly connected to both aggregate modules.

The synchronisation interface on the miscellaneous modules is independently connected to both aggregate modules when using two miscellaneous modules. The interfaces will be controlled from the active aggregate module.

READ MORE: **“Synchronisation” on page 7-52**

Auxiliary interface

The module has the physical interface and connector for the auxiliary interface. It is directly connected to both aggregate modules.

The auxiliary interface on the miscellaneous modules is independently connected to both aggregate modules when using two miscellaneous modules. The interfaces will be controlled from the active aggregate module.

READ MORE: **“AUX” on page 7-55**

Management interface

The module has the physical interface and connector for the management interface. It is directly connected to relevant aggregate module. It also includes the corresponding LEDs.

The management interface on the miscellaneous modules is independently connected to both aggregate modules when using two miscellaneous modules. The interfaces will be controlled from the active aggregate module.

READ MORE: **“CLI” on page 7-56**

Alarm interface

The external alarm interface includes eight alarm inputs and three alarm outputs.

The alarm inputs and alarm outputs are all controlled from the I2C bus.

The alarm interfaces on the miscellaneous modules are independently connected to both aggregate modules when using two miscellaneous modules. The interfaces will be controlled from the active aggregate module.

READ MORE: **“ALARM” on page 7-57**

LED indicators

Visual indicators (LEDs) provide the status of the AXXMETRO. The LEDs are placed on the front of the miscellaneous module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
PWR	Green	The power supply voltage is within the requirements when the LED is green
SYN	Green	The synchronisation input is within the requirements when the LED is green
EXT IN	Yellow	One or more external alarm inputs are active when the LED is yellow
EXT OUT	Yellow	One or more external alarm outputs are active when the LED is yellow
FAN	Red/Yellow	A fan failure, which does not lead to system failure, is active when the LED is Yellow A fan failure, which does lead to system failure, is active when the LED is Red.
ST	Green	This LED indicates the status of the management port The link is down if the LED is extinguished The link is up if the LED is green The link is up and receiving or transmitting traffic when the LED is blinking green
SP	Yellow/Green	This LED indicates the speed of the management port The link speed is 10 Mbps when the LED is yellow The link speed is 100 Mbps when the LED is green

Table 3.3. LED functionality on MM-1

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

READ MORE: **“Synchronisation” on page 7 -36**
“AUX” on page 7-55
“10 Base-T” on page 7-25
“ALARM” on page 7-57

3.5 FM-FAN

3.5.1 Overview

This is a fan module that supports 6 fans. It includes fan alarm monitoring circuits for all fans.

It consists of the following functionality:

- 6 Fans
- Filter
- Inventory EEPROM
- Local power supply

3.5.2 Features

Fans

The module includes six fans for improving the airflow through the AXXMETRO shelf. The fans run at full speed without any intervention from the active aggregate module.

The active aggregate module may reduce the speed of the fans by sending a command every second to the fan module. The fans switch back to full speed if a command is not detected in five seconds.

It is possible to change a fan module without affecting the rest of the system in the shelf.

The replacement fan module must be inserted within 1 minute to avoid overheating.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains two -48V to 14/24V non-isolated power supplies. The power is fed from both MM power supply interfaces through wire-or diodes. The power supplies include an EMC filter.

Fuses protect both power supplies. The fan module must be removed from the AXXMETRO shelf to change the fuses.

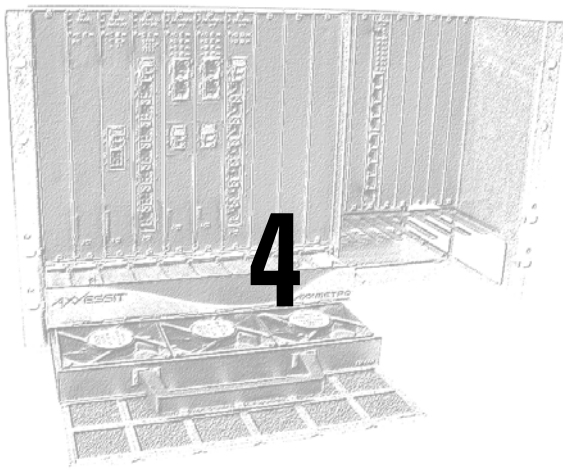
Power Consumption

18W

Filters

There is room for a fan filter. It can be of one time using type or of a washable type.

TRIBUTARY MODULES



4.1 TM-1XSTM16-SFP

4.1.1 Overview

This is a tributary module that supports one STM-16 interface.

It offers the following functionality:

- One traffic interface
- SDH features
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply
- Redundant connection to 2 aggregate modules for TDM, DCC, AUX and Synch traffic

4.1.2 Features

Traffic interface

The traffic interface includes full SDH processing before the traffic is connected to the back plane.

The traffic interfaces are based on the SFP multi source agreement (MSA) and it is possible to add the interface modules in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) must be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets all specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

The traffic interface only supports STM-16 line rate.

The following modules are supported:

- S-16.1 Short haul STM-16
- L-16.1 Medium haul STM-16

- L-16.2 Long haul STM-16
- "L-16.2C" CWDM STM-16 (8 wavelengths)

The optical interface is tilted downwards with an angle of 22.5 degrees.

SDH features

The tributary module includes the following SDH functionality:

- SDH termination for the interfaces

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The yellow LED state is not used.
SF	Yellow	The provisioned optical interface has an active alarm when the LED is Yellow.
SIG	Green/Yellow	An optical signal is present on a provisioned or un-provisioned optical interface when the LED is Green. An optical signal is not present on the provisioned interface when the LED is Yellow. If no signal is present and the optical interface is not provisioned the LED is extinguished.

Table 4.1. LED functionality on TM-1xSTM16-SFP

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. Two banks of configuration data are stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system. Automatic switchback to the old configuration data is performed if the new configuration data is not ok.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problems with the new.

The FPGAs are automatically configured at power up without intervention from the aggregate modules. It is also possible to configure the FPGAs from the active system controller, and an alarm will be raised if one or multiple FPGAs can not be configured.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

10W

4.2 TM-4XSTM4/1XSTM16-SFP

4.2.1 Overview

This is a tributary module that supports one STM-16 optical interface or four STM-4 optical interfaces.

It offers the following functionality:

- Traffic interfaces
- SDH features
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply
- Redundant connection to 2 aggregate modules for TDM, DCC, AUX and Synch traffic

4.2.2 Features

Traffic interfaces

The traffic interfaces include full SDH processing before the traffic is connected to the back plane.

The traffic interfaces are based on the SFP multi source agreement (MSA) and it is possible to add the interface modules in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) will be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meet all specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

One of the optical interfaces supports STM-16 or STM-4 line rate and the three other optical interfaces only supports STM-4 line rate. Note it is only possible to either use one STM-16 interface or from one to four STM-4 interfaces. It is not possible to mix STM-4 and STM-16 optical modules in the module.

The following modules are supported:

- S-4.1 Short haul STM-4
- L-4.1 Medium haul STM-4
- L-4.2 Long haul STM-4
- "L-4.2C" CWDM STM-4 (eight wavelengths)
- S-16.1 Short haul STM-16
- L-16.1 Medium haul STM-16
- L-16.2 Long haul STM-16
- "L-16.2C" CWDM STM-16 (eight wavelengths)

The optical interfaces are tilted downwards with an angle of 22.5 degrees.

SDH features

The tributary module includes the following SDH functionality:

- SDH termination for the interfaces

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The yellow state is not used.
SF	Yellow	One of the provisioned optical interfaces has an active alarm when the LED is Yellow.
SIG	Green/Yellow	Optical signals are present on all provisioned optical interfaces when the LED is Green. The LED is also green if no interfaces are provisioned and one or multiple optical signals are present on interfaces that are not provisioned. An optical signal is not present on one or multiple provisioned interfaces when the LED is Yellow. If no signals are present and the optical interfaces are not provisioned the LED is extinguished.Note that one LED is used for all optical interfaces.

Table 4.2. LED functionality on TM-4xSTM4/1xSTM16-SFP

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. Two banks of configuration data are stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware

download from the TMN system. Automatic switchback to the old configuration data is performed if the new configuration data is not ok.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problems with the new.

The FPGAs are automatically configured at power up without intervention from the aggregate modules. It is also possible to configure the FPGAs from the active system controller, and an alarm will be raised if one or multiple FPGAs can not be configured.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

19W

4.3 TM-4XSTM1/1XSTM4-SFP

4.3.1 Overview

This is a tributary module that supports one STM-4 or four STM-1 traffic interfaces.

It consists of the following functionality:

- Traffic interfaces
- SDH features
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply
- Redundant connection to 2 aggregate modules for TDM, DCC, AUX and Synch traffic

4.3.2 Features

Traffic interfaces

The traffic interfaces include full SDH processing before the traffic is connected to the back plane.

The traffic interfaces are based on the SFP multi source agreement (MSA) and it is possible to add the interface modules in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) will be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets all specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

One of the traffic interfaces supports both STM-1 and STM-4 line rate and the three other traffic interfaces only supports STM-1 line rate.

NOTE! **It is possible to either use one STM-4 interface or from one to four STM-1 interfaces.**

The following modules are supported:

- S-1.1 Short haul STM-1
- L-1.1 Medium haul STM-1
- L-1.2 Long haul STM-1
- "L-1-2C" CWDM STM-1 (eight wavelengths)
- STM-1e electrical interface (G.703)
- S-4.1 Short haul STM-4
- L-4.1 Medium haul STM-4
- L-4.2 Long haul STM-4
- "L-4.2C" CWDM STM-4 (8 wavelengths)

The optical interfaces are tilted downwards with an angle of 22.5 degrees.

SDH features

The tributary module includes the following SDH functionality:

- SDH termination for the interfaces

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The yellow state is not used.
SF	Yellow	One of the provisioned optical interfaces has an active alarm when the LED is Yellow.
SIG	Green/Yellow	Optical signals are present on all provisioned optical interfaces when the LED is Green. The LED is also green if no interfaces are provisioned and one or multiple optical signals are present on interfaces that are not provisioned. An optical signal is not present on one or multiple provisioned interfaces when the LED is Yellow. If no signals are present and the optical interfaces are not provisioned the LED is extinguished.Note that one LED is used for all optical interfaces.

Table 4.3. LED functionality on TM-4xSTM1/1xSTM4-SFP

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. Two banks of configuration data are stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system. Automatic switchback to the old configuration data is performed if the new configuration data is not ok.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problem with the new.

The FPGAs are automatically configured at power up without intervention from the aggregate modules. It is also possible to configure the FPGAs from the active system controller, and an alarm will be raised if one or multiple FPGAs can not be configured.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

15

4.4 TM-8XSTM1-SFP

4.4.1 Overview

This is a tributary module that supports eight STM-1 traffic interfaces.

It offers the following functionality:

- Traffic interfaces
- SDH features
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply
- Redundant connection to 2 aggregate modules for TDM, DCC, AUX and Synch traffic.

4.4.2 Features

Traffic interfaces

The optical interfaces include full SDH processing before the traffic is connected to the back plane.

The traffic interfaces are based on the SFP multi source agreement (MSA) and it is possible to add the interface modules in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) must be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets all specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

The traffic interfaces only support STM-1 line rate.

The following modules are supported:

- S-1.1 Short haul STM-1
- L-1.1 Medium haul STM-1

- L-1.2 Long haul STM-1
- "L-1.2C" (CWDM eight wavelengths)
- STM-1e electrical interface (G.703)

The optical interfaces are tilted downwards with an angle of 22.5 degrees.

SDH features

The tributary module includes the following SDH functionality:

- SDH termination for the interfaces

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The yellow state is not used.
SF	Yellow	One of the provisioned optical interfaces has an active alarm when the LED is Yellow.
SIG	Green/Yellow	Optical signals are present on all provisioned optical interfaces when the LED is Green. The LED is also green if no interfaces are provisioned and one or multiple optical signals are present on interfaces that are not provisioned. An optical signal is not present on one or multiple provisioned interfaces when the LED is Yellow. If no signals are present and the optical interfaces are not provisioned the LED is extinguished.Note that one LED is used for all optical interfaces.

Table 4.4. LED functionality on TM-8xSTM1-SFP

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. Two banks of configuration data are stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system. Automatic switchback to the old configuration data is performed if the new configuration data is not ok.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problem with the new.

The FPGAs are automatically configured at power up without intervention from the aggregate modules. It is also possible to configure the FPGAs from the active system controller, and an alarm will be raised if one or multiple FPGAs can not be configured.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

21W

4.5 TM-6XE3/T3

4.5.1 Overview

This is a tributary module that supports six E3 or T3 electrical interfaces.

It offers the following functionality:

- Traffic interfaces
- SDH features
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply

4.5.2 Features

Traffic interfaces

The module has six electrical E3 or T3 interfaces. It must be used together with a connector module (e.g. CM-6x1.0/2.3 or CM-PROT-6x1.0/2.3) to get access to the physical connector.

The interfaces can be configured individually as a transparent E3 interface or as a transparent T3 interface.

SDH features

The tributary module includes the following SDH functionality:

- E3/T3 line interfaces
- SDH termination for the interfaces

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The module is in standby state when the LED is Yellow.
SF	Yellow	One of the provisioned electrical interfaces has an active alarm when the LED is Yellow

Table 4.5. LED functionality on TM-6xE3/T3

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. Two banks of configuration data are stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system. Automatic switchback to the old configuration data is performed if the new configuration data is not ok.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problems with the new.

The FPGAs are automatically configured at power up without intervention from the aggregate modules. It is also possible to configure the FPGAs from the active system controller, and an alarm will be raised if one or multiple FPGAs can not be configured.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

12W

4.6 TM-63XE1

4.6.1 Overview

This is a tributary module that supports 63 E1 electrical interfaces.

It offers the following functionality:

- Traffic interfaces
- SDH features
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply
- Redundant connection to 2 aggregate modules for TDM, DCC, AUX and Synch traffic.

4.6.2 Features

Traffic interfaces

The module has 63 electrical E1 interfaces. It must be used together with a connector module (e.g. CM-2xLFH) to get access to the physical connectors.

The interfaces can be individually configured as transparent E1, ISDN PRA or G.704 interfaces.

SDH features

The tributary module includes the following SDH functionality:

- E1 line interfaces
- SDH termination for the interfaces

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The module is in standby state when the LED is Yellow.
SF	Yellow	One of the provisioned electrical interfaces has an active alarm when the LED is Yellow

Table 4.6. LED functionality on TM-63xE1

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. Two banks of configuration data are stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system. Automatic switchback to the old configuration data is performed if the new configuration data is not ok.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problem with the new.

The FPGAs are automatically configured at power up without intervention from the aggregate modules. It is also possible to configure the FPGAs from the active system controller, and an alarm will be raised if one or multiple FPGAs can not be configured.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

14W

4.7 TM-8XE1

4.7.1 Overview

This is a tributary module that supports 8 E1 electrical interfaces.

It offers the following functionality:

- Traffic interfaces
- SDH features
- LED indicators
- Configuration logic
- Inventory EEPROM

4.7.2 Features

Traffic interfaces

The module has 8 electrical E1 interfaces. It must be used together with a connector module (e.g. CM-8xRJ45) to get access to the physical connectors.

The interfaces can be individually configured as transparent E1, ISDN PRA or G.704 interfaces.

SDH features

The tributary module includes the following SDH functionality:

- E1 line interfaces
- SDH termination for the interfaces

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The module is in standby state when the LED is Yellow.
SF	Yellow	One of the provisioned electrical interfaces has an active alarm when the LED is Yellow

Table 4.7. LED functionality on TM-8xE1

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. Two banks of configuration data are stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system. Automatic switchback to the old configuration data is performed if the new configuration data is not ok.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problems with the new.

The FPGAs are automatically configured at power up without intervention from the aggregate modules. It is also possible to configure the FPGAs from the active system controller, and an alarm will be raised if one or multiple FPGAs can not be configured.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

8W

4.8 TM-8XFE-16XMAP-SFP

4.8.1 Overview

This is a tributary module that supports both optical and electrical Ethernet traffic interfaces. It supports up to 8 physical interfaces. The optical interfaces are an integral part of the module. The electrical interfaces are available on a dedicated connector module (e.g. CM-FE-8xRJ45).

It includes up to sixteen Ethernet to EOS mappers.

The module support both L1 and L2 services.

It offers the following functionality:

- Ethernet features
- SDH features
- Traffic interfaces
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply

4.8.2 Features

Ethernet features

The module supports L1 and L2 services. The L1 services are supported in all slots. The L2 services are only supported in slot 3, slot 4, slot 9 and slot 10.

The number of physical interfaces is eight. They can be configured independently as electrical 10/100 Base-TX or optical (100 Base-FX/LX10/ZX).

The policer performs the following functions:

- Q in Q tunneling of data
- L2 control protocol tunneling

- Rate adaptation, Flow control and Auto negotiation
- Internal connection between the physical interfaces, mapper and Ethernet switch

The module includes two 8-port Ethernet switches from which one is directly connected to 8 of the EOS mappers. This provides 8 EOS mappers that can be used in a L2 solution.

The other Ethernet switch is connected to the policer. Eight additional EOS mappers and eight physical interfaces are also connected to the policer.

The following options are available in the policer:

- A physical interface can be connected to the EOS mapper, via the policer, for an L1 service
- A physical interface can be connected to the Ethernet switch via the policer for an L2 service
- The port of the Ethernet switch can be connected to the EOS mapper, via the policer, for an additional EOS mapper.

Sixteen EOS mappers are available if none of the physical interfaces are used.

Four modes of operation are supported:

- 8xFE-L1 having 8 physical interfaces operating in L1 only
- 8xFE+8xMAP having 8 physical interfaces and 8 EOS mappers
- 2xFE+14xMAP having 2 physical interfaces and 14 EOS mappers
- 0xFE+16xMAP having no physical interfaces and 16 EOS mappers

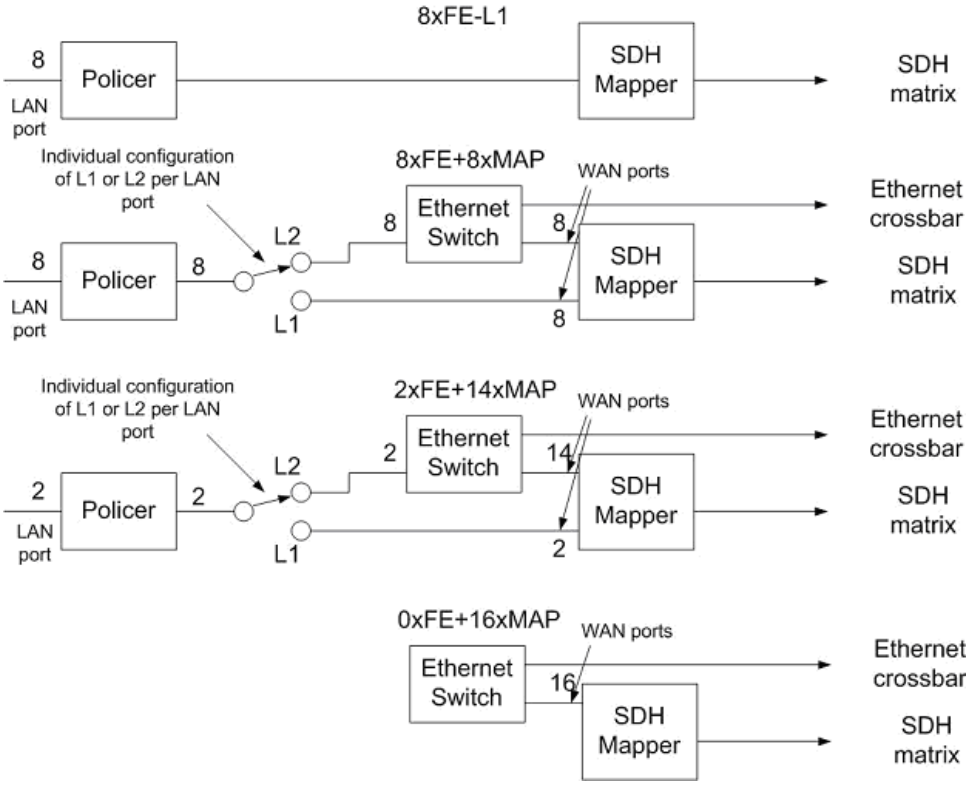


Figure 4-1. Illustrations of Operational modes for the FE module

SDH features

The tributary module includes the following SDH functionality:

- GFP-F encapsulation of Ethernet traffic
- Mapping of Ethernet traffic into NxVC-12, MxVC-3 or a single VC-4
- Support of Virtual Concatenation with NxVC-12, MxVC-3 (N=1..50 and M=1..3) or a single VC-4
- Support for up to 16 independent mappers
- Support for LCAS
- SDH termination

Traffic interfaces

The module supports up to eight electrical Ethernet interfaces. The PHY is placed on the respective connector module. The interfaces support both 10 Base-T and 100 Base-TX.

The number of electrical interfaces varies from 0-8 depending on the number of optical interfaces that are used.

The back plane interface is the RMII interface and eight is available for connection to the connector module.

There is room for 8 optical interfaces in the module. The optical interfaces only support FE.

The traffic interfaces are based on the SFP multi source agreement (MSA) and it is possible to add the interface modules in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) will be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets all specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

The following modules are supported:

- 100 Base-FX
- 100 Base-LX10
- "100 Base-ZX"

The optical interfaces are tilted downwards with an angle of 22.5 degrees.

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the tributary module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.

LED name	Colour	Functionality
ACT	Green/Yellow 	The module is in active state when the LED is Green.The yellow state is not used.
ST	Green 	The link is down if the LED is extinguished The link is up if the LED is green The link is up and receiving or transmitting traffic when the LED is blinking green Note that there are eight ST LEDs in the module, one for every optical interface.

Table 4.8. LED functionality on TM-8xFE-16xMAP-SFP

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. The configuration data is stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problem with the new.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.

Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

The +3.3V is also used to power the PHY on connector module. An electronic fuse protects the power output from failures in the connector cards.

Power Consumption

28W

4.9 TM-2XGE-2XMAP-SFP

4.9.1 Overview

This is a tributary module that supports both optical and electrical gigabit Ethernet traffic interfaces. It supports up to two interfaces. The optical and electrical interfaces are an integral part of the module.

It includes up to 2 Ethernet to EOS mappers.

The module support both L1 and L2 services.

It offers the following functionality:

- Ethernet features
- SDH features
- Traffic interfaces
- LED indicators
- Configuration logic
- Inventory EEPROM
- Local power supply

4.9.2 Features

Ethernet features

The module supports both L1 and L2 services.

The policer performs the following functions:

- Q in Q tunneling of data
- L2 control protocol tunneling
- Rate adaptation, Flow control and Auto negotiation
- Internal connection between the physical interfaces, mapper and Ethernet switch

The module includes two Ethernet switches and both are connected to the policer. The mapper and physical interface are also connected to the policer.

The following options are available in the policer:

- A physical interface can be connected to the mapper via the policer for an L1 service
- A physical interface can be connected to the Ethernet switch via the policer for an L2 service
- The port of the Ethernet switch can be connected to the mapper via the policer for an additional mapper.

Four modes of operation are supported:

- 2xGE/MAP having 2 physical interfaces supporting L1 Ethernet that are directly connected to 2 EOS mappers.
- 2xL2 without EOS mappers having 2 physical interfaces supporting L2 Ethernet and no EOS mappers.
- 1xGE-L1+1xGE-L2+1xMAP having a physical interface supporting L1 that is directly connected to an EOS mapper, a physical interfaces supporting L2 Ethernet and a freely available EOS mapper.
- 2xMAP having no physical interface and two available EOS mappers.

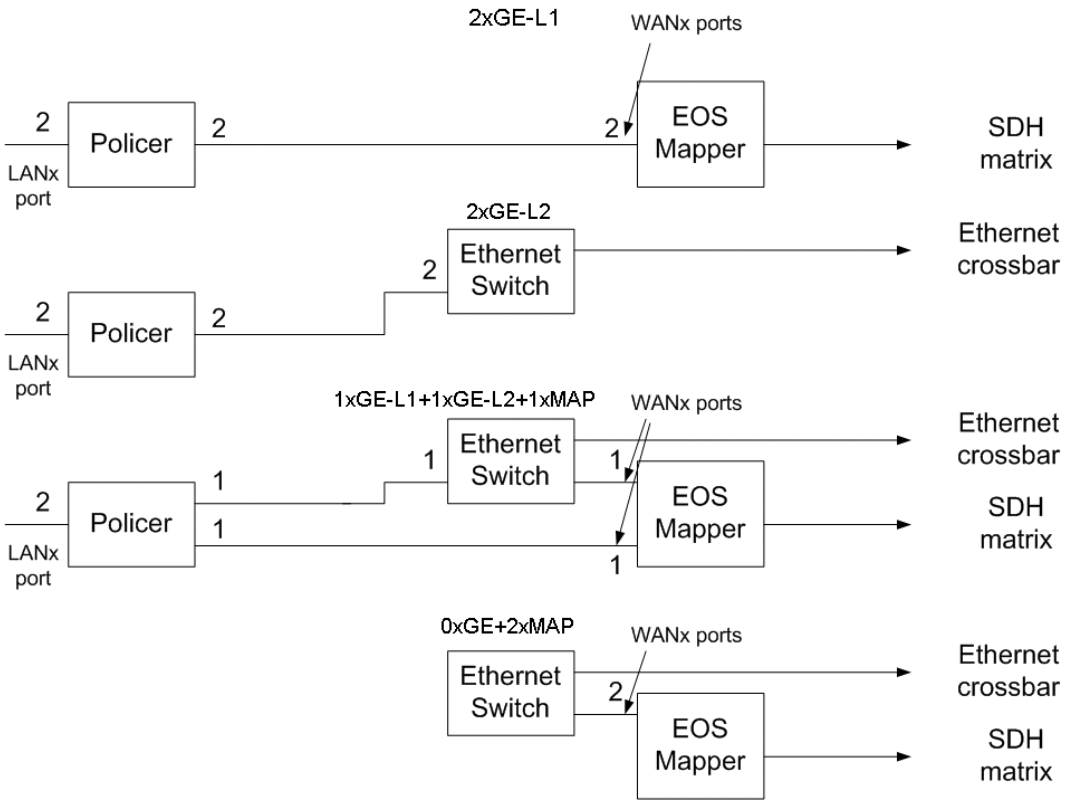


Figure 4-2. Illustration of operational modes for the GE module

SDH features

The tributary module includes the following SDH functionality:

- GFP-F encapsulation of Ethernet traffic
- Mapping of Ethernet traffic into NxVC-3 or MxVC-4
- Support of Virtual Concatenation with NxVC-3 or MxVC-4 (N=1..21 and M=1..7)
- Support for up to 2 independent EOS mappers
- Support for LCAS
- SDH termination

Traffic interfaces

There are room for two electrical or optical SFP interfaces in the module. The interfaces only support GE.

The traffic interfaces are based on the SFP multi source agreement (MSA) and it is possible to add the interface modules in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) must be issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets all specifications.

A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

The following modules are supported:

- 1000 Base-TX
- 1000 Base-SX
- 1000 Base-LX10
- 1000 Base-ZX
- GE-CWDM

The optical interfaces are tilted downwards with an angle of 22.5 degrees.

LED indicators

Visual indicators (LEDs) provide the status of the module. The LEDs are placed on the front of the aggregate module.

LED name	Colour	Functionality
MF	Red	A failure is detected in the module when the LED is Red.
ACT	Green/Yellow	The module is in active state when the LED is Green.The yellow state is not used.
ST	Green	The link is down if the LED is extinguished. The link is up if the LED is green. The link is up and receiving or transmitting traffic when the LED is blinking green Note that there are two ST LEDs in the module, one for each optical interface

Table 4.9. LED functionality on TM-2xGE-2xMAP-SFP

Configuration logic

A CPLD device performs the configuration of FPGAs in the module. The configuration data is stored in an onboard FLASH. The content of the FLASH can be upgraded with firmware download from the TMN system.

The FLASH stores both the new and the old configuration data to make it possible to revert to the old data if there are problem with the new.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Local power supply

The module contains a -48V to 3.3V isolated power supply. The power supply is fed from both MM power supply interfaces through wire-or diodes. The power supply includes an EMC filter.

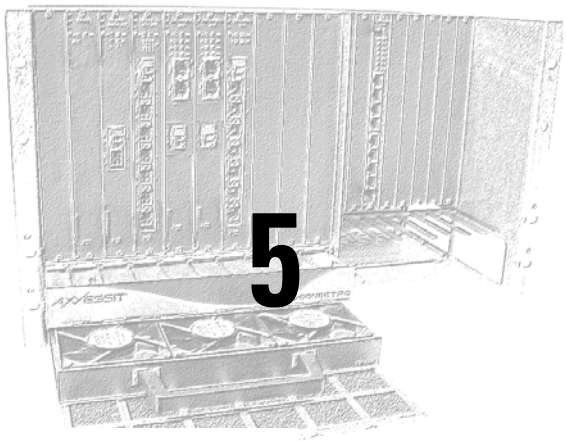
A fuse protects the power supply. The tributary module must be removed from the AXXMETRO shelf to change the fuse.Low voltage power supplies convert the +3.3V to the other voltages needed in the module.

The module monitors all secondary voltages and signals module failure if the voltages are outside specification.

Power Consumption

25W

CONNECTOR MODULES



READ MORE: **See Chapter , "Physical Interfaces." for more information about the physical interfaces for the different modules.**

5.1 CM-8XRJ45

5.1.1 Overview

This is a connector module that must be used together with certain tributary modules.

It offers the following functionality:

- RJ-45 Connectors for E1 interface
- Inventory EEPROM

Power Consumption

< 1W

5.1.2 Features

Connectors

The module has 8 RJ-45 connectors for use for E1 interfaces.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

5.2 CM-FEX8XRJ45

5.2.1 Overview

This is a connector module for Ethernet that must be used together with a tributary Ethernet module (e.g. TM-8xFE-16xMAP-SFP).

It offers the following functionality:

- RJ-45 connectors for LAN interfaces
- Ethernet interfaces
- LED indicators
- Inventory EEPROM

Power Consumption

4W

5.2.2 Features

Connectors

The module has 8 RJ-45 connectors for use for Ethernet interfaces.

Ethernet interfaces

The module has 8 physical 10 Base-T or 100 Base-TX Ethernet interfaces for Ethernet. It also includes the Ethernet PHY chip. The chip is powered from the tributary data module.

LED indicators

Visual indicators (LEDs) provide the status of the module interfaces. The LEDs are placed on the front of the connector module. Note that the total number of LEDs is sixteen with two LEDs for each interface.

LED name	Colour	Functionality
ST	Green	The link is down if the LED is extinguished. The link is up if the LED is green. The link is up and receiving or transmitting traffic when the LED is blinking green. There is one ST LED for each interface
SP	Yellow/Green	The link speed is 10 Mbps when the LED is yellow. The link speed is 100 Mbps when the LED is green There is one speed LED for each interface

Table 5.1. LED functionality on CM-FEx8xRJ45

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

Power interface for the PHY from the tributary module

5.3 CM-6X1.0/2.3

5.3.1 Overview

This is a connector module that must be used together with certain tributary modules.

It offers the following functionality:

- 1.0/2.3 Coaxial connectors for E3 and T3 interfaces.
- Inventory EEPROM

Power Consumption

< 1W

5.3.2 Features

Connectors

The module has 12 1.0/2.3 connectors for use for E3 and T3 interfaces.
6 x (1 in + 1 out), 6 interfaces.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

5.4 CM-PROT-6X1.0/2.3

5.4.1 Overview

This is a connector module that must be used together with certain tributary modules.

The module is of double width and plugs into both the odd an even slot position.

It offers the following functionality:

- 1.0/2.3 Coaxial connectors for E3 and T3 interfaces
- Protection switch
- Inventory EEPROM

Power Consumption

1W

5.4.2 Features

Connectors

The module has 12 1.0/2.3 connectors for use for E3 and T3 interfaces. 6x(1 in + 1 out), 6 interfaces.

Protection switch

The module includes protection-switching relays. The relays are controlled from the active I2C bus.

The relays are powered from the -48V supply and the card includes a fuse for protection against internal failures.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

5.5 CM-2XLFH

5.5.1 Overview

This is a connector module that must be used together with certain tributary modules.

It offers the following functionality:

- LFH connectors for E1 interfaces
- Inventory EEPROM

Power Consumption

< 1W

5.5.2 Features

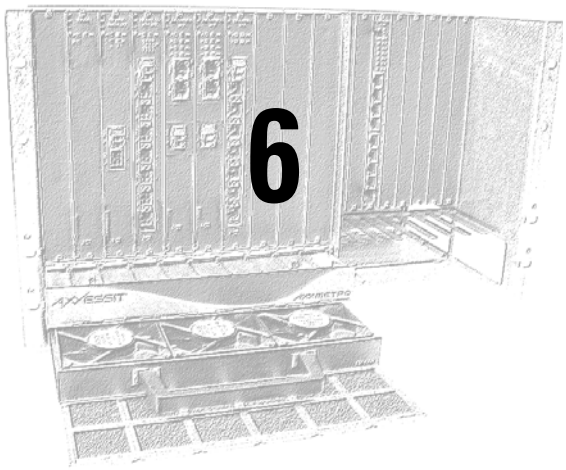
Connectors

The module has 2 LFH connectors for use for E1 interfaces.

Inventory EEPROM

The module includes an inventory EEPROM that is connected to both I2C buses. It is powered from the auxiliary power supply from the two aggregate modules.

REMOTE UNITS



6.1 INTRODUCTION

3 patch panels and a LFH cable are available for patching the 63 E1's interface on the High Density 63xE1 module.

6.2 120 OHM PATCH PANEL (32XE1-LFH-RJ45)

This is a patch panel for the multi interface E1 connector. One connector can have up to 32 E1interfaces.

The panel has 32 RJ-45 connectors for the E1 interfaces and one multi interface connector for connection to the module.

Cables with predefined lengths are also available (e.g. 3 m, 10 m and 25 m).

The patch panel meets the full requirements of ITU-T G.703 for 3m and 10 m.

NOTE! **The 25m cable does not fulfill all requirements specified in G.703. The pulse mask is not fulfilled because of cable attenuation. The return loss requirement may also not be fulfilled because of the cable characteristic. Neither of these issues will be a problem for the application.**

The cables are used to connect the patch panel to the multi interface E1 module.

The patch panel can be mounted in 19" or ETSI racks and the height is 1 RU (44 mm).

Figure 6-1. Overview 32xE1-LFH-RJ45 Panel

Figure 6-2. Detail 32xE1-LFH-RJ45 Panel

Pin Out

Pin	Signal
1	P120 OUT
2	N120 OUT
3	GND
4	P120 IN
5	N120 IN
6	SHIELD
7	NC
8	NC

Table 6.1. RJ-45 Connector Pin Out

6.3 75 OHM PATCH PANEL (32XE1-LFH-1.0/2.3)

This is a patch panel for the multi interface E1 connector. One connector can have up to 32 E1 interfaces.

The patch panel has 64 1.0/2.3 connectors for the E1 interfaces and one multi interface connector for connection to the module. The patch panel includes baluns for all interfaces and transforms the impedance from 75 ohm to 120 ohm.

Cables with predefined lengths are also available (e.g. 3 m, 10 m and 25 m).

The patch panel meets the full requirements of ITU-T G.703 for 3 m and 10 m.

NOTE! **The 25m cable does not fulfill all requirements specified in G.703. The pulse mask is not fulfilled because of cable attenuation. The return loss requirement may also not be fulfilled because of the cable characteristic. Neither of these issues will be a problem for the application.**

The cables are used to connect the patch panel to the multi interface E1 module.

The patch panel can be mounted in 19" or ETSI racks and the height is 1 RU (44 mm).

Figure 6-3. Overview 32xE1-LFH-1.0/2.3

Figure 6-4. Detail 32xE1-LFH-1.0/2.3

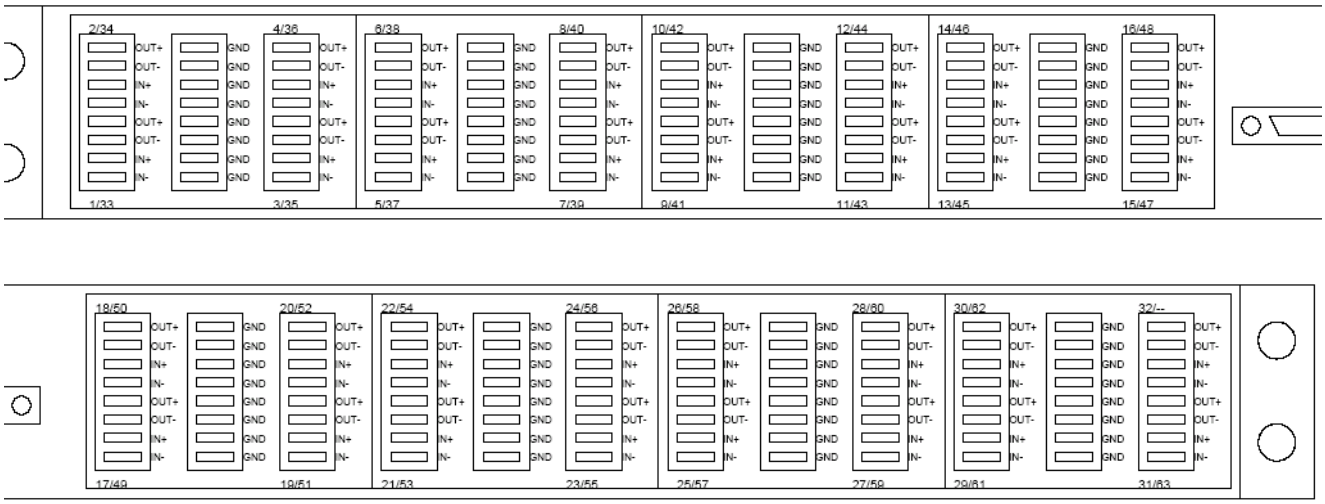
This is a patch panel for the multi interface E1 connector. One connector can have up to 32 E1 interfaces.

The patch panel has 32 1.0/2.3 connectors for the E1 interfaces and one LFH connector for connection to the module. The patch panel interface impedance is 75 ohm. The 32XE1 LFH - LFH patch cable must be used to connect the patch panel to the multi interface E1 module. The patch panel can be mounted in 19” or ETSI racks and the height is 1U (44 mm).

6.4 120 OHM PATCH PANEL (32XE1-LFH-KRONE)

This is a patch panel for the multi interface E1 connector. One connector can have up to 32 E1 interfaces.

The patch panel has 24 8 pins Krone connectors for the E1 interfaces and one multi interface connector for connection to the module.



Cables with predefined lengths are also available (e.g. 3 m, 10 m and 25 m).

The patch panel meets the full requirements of ITU-T G.703 for 3 m and 10 m.

NOTE! **The 25m cable does not fulfill all requirements specified in G.703. The pulse mask is not fulfilled because of cable attenuation. The return loss requirement may also not be fulfilled because of the cable characteristic. Neither of these issues will be a problem for the application.**

The cables are used to connect the patch panel to the multi interface E1 module.

The patch panel can be mounted in 19" or ETSI racks and the height is 1 RU (44 mm).

6.5 32XE1 LFH - LFH CABLE

WARNING! **Only use LFH-cables with straight connector when connecting to AXXMETRO modules. See Figure 6-5.**

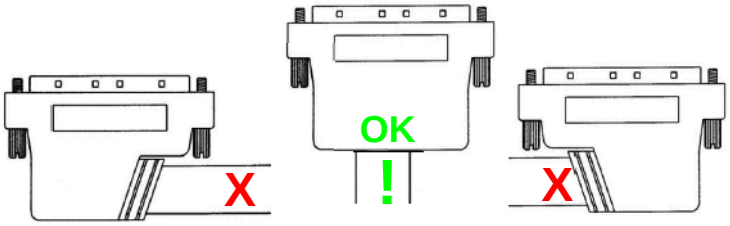


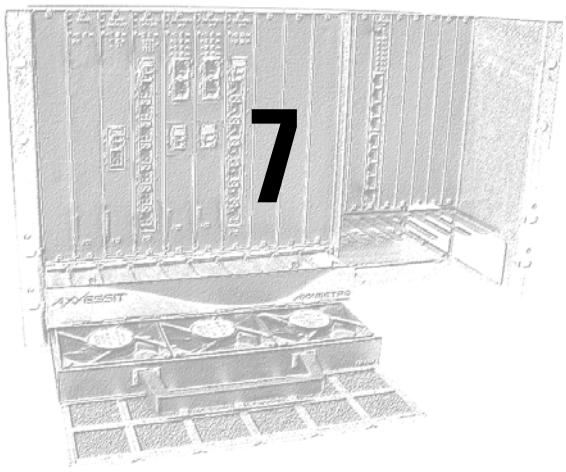
Figure 6-5. Orientation of connector - LFH cable

WARNING! **To protect the cable jacket, avoid sharp edges and excessive bending. Always fasten the cable connectors with both fixing screws. If the connector is fixed with one screw only, this screw is likely to break if the cable is pulled by accident.**

Available patch cable lengths are:

- 3 M
- 10 M
- 25 M

PHYSICAL INTERFACES



7.1 STM-1 SHORT HAUL INTERFACE (S-1.1)

This is an optical STM-1 short haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	155 520 kbps
Wavelength range	1261 - 1360 nm
Transmitter at reference point S	
Source type	MLM
Spectral characteristics (max. RMS width)	7.7 nm
Mean launched power (max.)	-8 dBm
Mean launched power (min.)	-15 dBm
Minimum extinction ratio	8.2 dB
Optical path between S and R	
Attenuation range	0 - 12 dB
Maximum tolerable dispersion	96 ps/nm
Minimum optical return loss	NA
Maximum discrete reflectance between S and R	NA
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-28 dBm
Minimum overload	-8 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	NA

Table 7.1. Optical budget S-1.1 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 2
Optical output power	G.957 06/1999 Table 2
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 2
Receiver sensitivity	G.957 06/1999 Table 2
Receiver overload	G.957 06/1999 Table 2
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 2
LOS is detected between minimum RX sensitivity and -45 dBm.	

Table 7.2. S-1.1 physical compliance

7.2 STM-1 MEDIUM HAUL INTERFACE (L-1.1)

This is an optical STM-1 medium haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	155 520 kbps
Wavelength range	1263- 1360nm
Transmitter at reference point S	
Source type	SLM
Spectral characteristics (max. RMS width)	NA
Maximum -20 dB width	1
Minimum side mode suppression ratio	30
Mean launched power (max.)	0 dBm
Mean launched power (min.)	-5 dBm
Minimum extinction ratio	10 dB
Optical path between S and R	
Attenuation range	10 - 28 dB
Maximum tolerable dispersion	NA
Minimum optical return loss	NA
Maximum discrete reflectance between S and R	NA
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-34 dBm
Minimum overload	-10 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	NA

Table 7.3. Optical budget L-1.1 interface

Detail	Compliance to Specification
Type of optical fiber	G.652 03/2003
Format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 2
Optical output power	G.957 06/1999 Table 2
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 2
Receiver sensitivity	G.957 06/1999 Table 2
Receiver overload	G.957 06/1999 Table 2
Reflectance of receiver	G.957 06/1999 Table 2
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 2
LOS is detected between minimum RX sensitivity and -45 dBm.	

Table 7.4. L-1.1 physical compliance

7.3 STM-1 LONG HAUL INTERFACE (L-1.2)

This is an optical STM-1 long haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	155 520 kbps
Wavelength range	1480- 1580 nm
Transmitter at reference point S	
Source type	SLM
Spectral characteristics (max. RMS width)	NA
Maximum -20 dB width	1
Minimum side mode suppression ratio	30
Mean launched power (max.)	0 dBm
Mean launched power (min.)	-5 dBm
Minimum extinction ratio	10 dB
Optical path between S and R	
Attenuation range	10 - 28 dB
Maximum tolerable dispersion	NA
Minimum optical return loss	20
Maximum discrete reflectance between S and R	-25
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-34 dBm
Minimum overload	-10 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-25 dB

Table 80 Optical budget L-1.2 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 2
Optical output power	G.957 06/1999 Table 2
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 2
Receiver sensitivity	G.957 06/1999 Table 2
Receiver overload	G.957 06/1999 Table 2
Reflectance of receiver	G.957 06/1999 Table 2
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Meet all safety requirements in specification	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS will be detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 2
Reflectance of receiver according to specification	G.957 06/1999 Table 2

Table 7.5. L-1.2 physical compliance requirements

7.4 STM-1 CWDM LONG HAUL INTERFACE ("L-1.2C")

This is an optical STM-1 CWDM long haul interface with support for eight wavelengths. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	155 520 kbps
Wavelengths	1471, 1491, 1511, 1531, 1551, 1571, 1591 and 1611 nm
Wavelength variation over temperature	+/- 7.5 nm
Transmitter at reference point S	
Source type	SLM
Spectral characteristics (max. RMS width)	NA
Maximum -20 dB width	1
Minimum side mode suppression ratio	30
Mean launched power (max.)	0 dBm
Mean launched power (min.)	-5 dBm
Minimum extinction ratio	10 dB
Optical path between S and R	
Attenuation range	10 - 28 dB
Maximum tolerable dispersion	NA
Minimum optical return loss	20
Maximum discrete reflectance between S and R	-25
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-34 dBm
Minimum overload	-10 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-25 dB

Table 7.6. Optical budget "L-1.2C" interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 2
Optical output power	G.957 06/1999 Table 2
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 2
Receiver sensitivity	G.957 06/1999 Table 2
Receiver overload	G.957 06/1999 Table 2
Reflectance of receiver	G.957 06/1999 Table 2
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 2
LOS is detected between minimum RX sensitivity and -45 dBm.	
Reflectance of receiver according to specification	G.957 06/1999 Table 2

Table 7.7. "L-1.2C" physical compliance requirements

7.5 ELECTRICAL STM-1 (STM-1E)

This is a 155 Mbps STM-1e, 75 ohm coaxial interface according to ITU-T G.703,.

Detail	Compliance to Specification
Frequency tolerance for STM-1	G.703 11/2001 ch.15.1
The format of the signal	G.707 10/2000
CMI signal coding	G.703 11/2001 ch.15.1
Output pulse shapes for 75 ohm for STM-1E	G.703 11/2001 ch.15.2
Output return loss for STM-1E	G.703 11/2001 ch.15.2
Cable attenuation for STM-1E	G.703 11/2001 ch.15.3
Input return loss for STM-1E	G.703 11/2001 ch.15.3
Interfering signal for STM-1E	G.703 11/2001 ch.15.3
Grounded input and output shield for STM-1E	G.703 11/2001 ch.15.5

Detail	Compliance to Specification
Input jitter and wander for STM-1E	G.825 03/2000 ch 6.1.2.1
Output jitter for STM-1E	G.825 03/2000 ch 5.1
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998

Table 7.8. STM-1e physical compliance requirement

The physical connector is a 1.0/2.3 coaxial type. The screen on the input and on the output connector is DC coupled to ground.

7.6 STM-4 SHORT HAUL INTERFACE (S-4.1)

This is an optical STM-4 short haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	622 080kbps
Wavelength range	1274-1356nm
Transmitter at reference point S	
Source type	MLM
Spectral characteristics (max. RMS width)	2.5 nm
Mean launched power (max.)	-8 dBm
Mean launched power (min.)	-15 dBm
Minimum extinction ratio	8.2 dB
Optical path between S and R	
Attenuation range	0 - 12 dB
Maximum tolerable dispersion	74 ps/nm
Minimum optical return loss	NA
Maximum discrete reflectance between S and R	NA
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-28 dBm
Minimum overload	-8 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	NA

Table 7.9. Optical budget S-4.1 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 3
Optical output power	G.957 06/1999 Table 3
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 3
Receiver sensitivity	G.957 06/1999 Table 3
Receiver overload	G.957 06/1999 Table 3
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 3

Table 7.10. S-4.1 physical compliance

7.7 STM-4 MEDIUM HAUL INTERFACE (L-4.1)

This is an optical STM-4 medium haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	622 080kbps
Wavelength range	1280 - 1355 nm
Transmitter at reference point S	
Source type	SLM
Spectral characteristics (max. RMS width)	NA
Maximum -20 dB width	<1
Minimum side mode suppression ratio	30
Mean launched power (max.)	+2 dBm
Mean launched power (min.)	-3 dBm
Minimum extinction ratio	10 dB
Optical path between S and R	
Attenuation range	10-24 dB
Maximum tolerable dispersion	NA
Minimum optical return loss	20 dB
Maximum discrete reflectance between S and R	-25 dB
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-28 dBm
Minimum overload	-8 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-14 dB

Table 7.11. Optical budget L-4.1 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 3
Optical output power	G.957 06/1999 Table 3
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 3
Receiver sensitivity	G.957 06/1999 Table 3
Receiver overload	G.957 06/1999 Table 3
Reflectance of receiver	G.957 06/1999 Table 3
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements in specification	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS will be detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 3
Reflectance of receiver according to specification	G.957 06/1999 Table 3

Table 7.12. Table 88 L-4.1 physical compliance requirements

7.8 STM-4 LONG HAUL INTERFACE (L-4.2)

This is an optical STM-4 long haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	622 080kbps
Wavelength range	1480 - 1580 nm
Transmitter at reference point S	
Source type	SLM
Spectral characteristics (max. RMS width)	NA
Maximum -20 dB width	<1
Minimum side mode suppression ratio	30
Mean launched power (max.)	+2 dBm
Mean launched power (min.)	-3 dBm
Minimum extinction ratio	10 dB
Optical path between S and R	
Attenuation range	10-24 dB
Maximum tolerable dispersion	NA
Minimum optical return loss	24 dB
Maximum discrete reflectance between S and R	-27 dB
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-28 dBm
Minimum overload	-8 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-27 dB

Table 7.13. Optical budget L-4.2 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 3
Optical output power	G.957 06/1999 Table 3
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 3
Receiver sensitivity	G.957 06/1999 Table 3
Receiver overload	G.957 06/1999 Table 3
Reflectance of receiver	G.957 06/1999 Table 3
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS will be detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 3
Reflectance of receiver according to specification	G.957 06/1999 Table 3

Table 7.14. L-4.2 physical compliance requirements

7.9 STM-4 CWDM LONG HAUL INTERFACE ("L-4.2C")

This is an optical STM-4 CWDM long haul interface with support for up to 8 wavelengths. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	622 080kbps
Wavelengths	1471 nm 1491 nm 1511 nm 1531 nm 1551 nm 1571 nm 1591 nm 1611 nm
Wavelength variation over temperature	+/- 7.5 nm
Transmitter at reference point S	
Source type	SLM
Spectral characteristics (max. RMS width)	NA
Maximum -20 dB width	<1
Minimum side mode suppression ratio	30
Mean launched power (max.)	+2 dBm
Mean launched power (min.)	-3 dBm
Minimum extinction ratio	10 dB
Optical path between S and R	
Attenuation range	10-24 dB
Maximum tolerable dispersion	NA
Minimum optical return loss	24 dB
Maximum discrete reflectance between S and R	-27 dB
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-28 dBm
Minimum overload	-8 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-27 dB

Table 7.15. Optical budget "L-4.2C" interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 3
Optical output power	G.957 06/1999 Table 3
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 3
Receiver sensitivity	G.957 06/1999 Table 3
Receiver overload	G.957 06/1999 Table 3
Reflectance of receiver	G.957 06/1999 Table 3
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 3
Reflectance of receiver according to specification	G.957 06/1999 Table 3
Wavelengths according to specification	G.694.2 12/2003

Table 7.16. "L-4.2C" physical compliance requirements

7.10 STM-16 SHORT HAUL INTERFACE (S-16.1)

This is an optical STM-16 short haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	2488 380 kbps
Wavelength range	1261 - 1360 nm
Transmitter at reference point S	
Source type	SLM
Maximum -20dB width	1nm
minimum side mode suppression ratio	30dB
Mean launched power (max.)	0dBm
Mean launched power (min.)	-5 dBm
Minimum extinction ratio	8.2 dB
Optical path between S and R	
Attenuation range	0 - 12 dB
Maximum tolerable dispersion	NA
Minimum optical return loss at S inc. any connectors	24dB
Maximum discrete reflectance between S and R	-27dB
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-18 dBm
Minimum overload	0 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-27dB

Table 7.17. Optical budget S-16.1 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 4
Optical output power	G.957 06/1999 Table 4
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 4
Receiver sensitivity	G.957 06/1999 Table 4
Receiver overload	G.957 06/1999 Table 4
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 3

Table 94 S-16.1 physical compliance requirements

7.11 STM-16 MEDIUM HAUL INTERFACE (L-16.1)

This is an optical STM-16 medium haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	2488 380 kbps
Wavelength range	1280 - 1355 nm
Transmitter at reference point S	
Source type	SLM
Maximum -20dB width	1nm
minimum side mode suppression ratio	30dB
Mean launched power (max.)	+3 dBm
Mean launched power (min.)	-2 dBm
Minimum extinction ratio	8.2 dB
Optical path between S and R	
Attenuation range	10 - 24 dB
Maximum tolerable dispersion	NA
Minimum optical return loss at S inc. any connectors	24dB
Maximum discrete reflectance between S and R	-27dB
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-27 dBm
Minimum overload	-9 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-27dB

Table 7.18. Optical budget L-16.1 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 4
Optical output power	G.957 06/1999 Table 4
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 4
Receiver sensitivity	G.957 06/1999 Table 4
Receiver overload	G.957 06/1999 Table 4
Reflectance of receiver	G.957 06/1999 Table 4
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 4

Table 7.19. L-16.1 physical compliance requirements

7.12 STM-16 LONG HAUL INTERFACE (L-16.2)

This is an optical STM-16 long haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	2488 380 kbps
Wavelength range	1500 - 1580 nm
Transmitter at reference point S	
Source type	SLM
Maximum -20dB width	< 1nm
minimum side mode suppression ratio	30dB
Mean launched power (max.)	+3 dBm
Mean launched power (min.)	-2 dBm
Minimum extinction ratio	8.2 dB
Optical path between S and R	
Attenuation range	10 - 24 dB
Maximum tolerable dispersion	1200-1600 ps/nm
Minimum optical return loss at S inc. any connectors	24dB
Maximum discrete reflectance between S and R	-27dB
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-28 dBm
Minimum overload	-9 dBm
Maximum optical path penalty	2 dB
Maximum reflectance at R	-27dB

Table 7.20. Optical budget L-16.2 interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 4
Optical output power	G.957 06/1999 Table 4
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 4
Receiver sensitivity	G.957 06/1999 Table 4
Receiver overload	G.957 06/1999 Table 4
Reflectance of receiver	G.957 06/1999 Table 4
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 4
Reflectance of receiver according to specification	G.957 06/1999 Table 4

Table 7.21. L-16.2 physical compliance requirements

7.13 STM-16 CWDM LONG HAUL INTERFACE ("L-16.2C")

This is an optical STM-16 long haul interface with support for up to 8 wavelengths. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	2488 380 kbps
Wavelengths	1471 nm 1491 nm 1511 nm 1531 nm 1551 nm 1571 nm 1591 nm 1611 nm
Wavelength variation over temperature	+/-7.5 nm
Transmitter at reference point S	
Source type	SLM
Maximum -20dB width	< 1nm
minimum side mode suppression ratio	30dB
Mean launched power (max.)	+3 dBm
Mean launched power (min.)	-2 dBm
Minimum extinction ratio	8.2 dB
Optical path between S and R	
Attenuation range	10 - 24 dB
Maximum tolerable dispersion	1200-1600 ps/nm
Minimum optical return loss at S inc. any connectors	24dB
Maximum discrete reflectance between S and R	-27dB
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-28 dBm
Minimum overload	-9 dBm
Maximum optical path penalty	2 dB
Maximum reflectance at R	-27dB

Table 7.22. Optical budget "L-16.2C" interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 4
Optical output power	G.957 06/1999 Table 4
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 4
Receiver sensitivity	G.957 06/1999 Table 4
Receiver overload	G.957 06/1999 Table 4
Reflectance of receiver	G.957 06/1999 Table 4
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 4
Reflectance of receiver according to specification	G.957 06/1999 Table 4

Table 7.23. "L-16.2C" physical compliance requirements

7.14 10 BASE-T

This is a 10 Base-T Ethernet interface according to the IEEE 802.3 specification.

The connectors are RJ-45 connectors, with the following pin-out:

Pin	Signal
1	TxD+
2	TxD-
3	RxD+
4	NC
5	NC
6	RxD-
7	NC
8	NC

Table 7.24. Pin-out 10 Base-T Ethernet port

Detail	Compliance to Specification
Supports UTP-5 cabling	802.3 2002 ch 25.4.6
Minimum 100m of cable	802.3 2002 ch 25.4.6
Isolation requirement	802.3 2002 ch 14.3.1.1
Transmitter specifications	802.3 2002 ch 14.3.1.2
Differential output voltage	802.3 2002 ch 14.3.1.2.1
Transmitter differential output impedance	802.3 2002 ch 14.3.1.2.2
Output timing jitter	802.3 2002 ch 14.3.1.2.3
Transmitter impedance balance	802.3 2002 ch 14.3.1.2.4
Common-mode output voltage	802.3 2002 ch 14.3.1.2.5
Transmitter common-mode rejection	802.3 2002 ch 14.3.1.2.6
Transmitter fault tolerance	802.3 2002 ch 14.3.1.2.7
Receiver differential input signals	802.3 2002 ch 14.3.1.3.1
Receiver differential noise immunity	802.3 2002 ch 14.3.1.3.2
Idle input behavior	802.3 2002 ch 14.3.1.3.3
Receiver differential input impedance	802.3 2002 ch 14.3.1.3.4
Common-mode rejection	802.3 2002 ch 14.3.1.3.5
Receiver fault tolerance	802.3 2002 ch 14.3.1.3.6
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998
Surge over voltage at unshielded balanced signal lines	K.41 05/1998

Table 7.25. 10 Base-T physical compliance requirements

7.15 100 BASE-TX

This is a 100Base-TX Ethernet interface according to the IEEE 802.3 specification.

The RJ-45 connectors have the following pin-out:

Pin	Signal
1	TxD+
2	TxD-
3	RxD+
4	NC
5	NC
6	RxD-
7	NC
8	NC

Table 7.26. Pin-out Fast Ethernet port

Detail	Compliance to Specification
Pinout according to Table 103	802.3 2002 ch 25.4.3
Supports UTP-5 cabling	802.3 2002 ch 25.4.6
Minimum 100m of cable	802.3 2002 ch 25.4.6
UTP test load	X3.263 1995 9.1.2.1
UTP differential output voltage	X3.263 1995 9.1.2.2
Waveform overshoot	X3.263 1995 9.1.3
Signal amplitude symmetry	X3.263 1995 9.1.4
Return loss	X3.263 1995 9.1.5
Rise/fall times	X3.263 1995 9.1.6
Worst case droop of transformer	X3.263 1995 9.1.7
Duty cycle distortion (DCD)	X3.263 1995 9.1.8
Jitter	X3.263 1995 9.1.9
Differential input impedance	X3.263 1995 9.2.2
Common-mode rejection	X3.263 1995 9.2.3
Signal Detect assertion threshold	X3.263 1995 10.1.1.1
Signal Detect de assertion threshold	X3.263 1995 10.1.1.2
Signal Detect timing requirements on assertion	X3.263 1995 10.1.2
Signal Detect timing requirements on desertion	X3.263 1995 10.1.3
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998
Surge over voltage at unshielded balanced signal lines	K.41 05/1998

Table 7.27. Fast Ethernet physical compliance requirements

7.16 100 BASE-FX

This is a Fast Ethernet (FE) interface that meets the 100 Base-FX specifications in IEEE 802.3. It is an optical short haul interface based on multi-mode fiber.

Description	62.5 µm MMF	Unit
Transmitter type	Shortwave Laser	
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1270 to 1380	nm
Trise	3.5	ns
Tfall	3.5	ns
Average launch power (max)	-14	dBm
Average launch power (min)	-20	dBm
Duty Cycle Distortion peak-peak	1	ns
Data Dependent Jitter peak-peak	0.6	ns
Random Jitter peak-peak	0.76	ns
Extinction ratio (min)	9	dB

Table 7.28. Table 105 Transmitter characteristic for 100 Base-FX

Description	62.5 µm	Unit
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1270 - 1380	nm
Average receive power (max)	-14	dBm
Receive sensitivity	-31	dBm
Trise	5	ns
Tfall	5	ns
Duty Cycle Distortion peak-peak	1	ns
Data Dependent Jitter peak-peak	1.2	ns
Random Jitter peak-peak	0.76	ns

Table 7.29. Receiver characteristic for 100 Base-FX

Detail	Compliance to Specification
Transmitter speed	802.3 2002
Wavelength	ISO9314-3 :1990 ch 8.1
Spectral width	ISO9314-3 :1990 ch 8.1.1
Trise and Tfall	ISO9314-3 :1990 ch 8.1
Output power	ISO9314-3 :1990 ch 8.1
Extinction ratio	ISO9314-3 :1990 ch 8.1
Duty cycle distortion	ISO9314-3 :1990 ch 8.1
Pulse mask	ISO9314-3 :1990 ch 8.1.2
Receiver speed	ISO9314-3 :1990 ch 8.2
Wavelength	ISO9314-3 :1990 ch 8.2
Maximum input power	ISO9314-3 :1990 ch 8.2
Receive sensitivity	ISO9314-3 :1990 ch 8.2
Jitter	ISO9314-3 :1990 ch 8.1
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5

Table 7.30. 100 Base-FX physical compliance

7.17 100 BASE-LX10

This is a Fast Ethernet (FE) interface that meets the 100 Base-LX10 specifications in IEEE 802.3. This interface is an optical short haul interface based on single-mode fiber.

Description	Type B1.1, B1.3 SMF	Unit
Transmitter type (a)	Longwave laser	
Signaling speed (range)	125 ± 50 ppm	MBd
Operating wavelength range (b)	1260 to 1360	nm
RMS spectral width (max)	7.7	nm
Average launch power (max)	-8	dBm
Average launch power (min)	-15	dBm
Average launch power of OFF transmitter (max)	-45	dBm
Extinction ratio (min)	5	dB
RIN12OMA (c) (max)	-110	dB/Hz
Optical return loss tolerance (max)	12	dB
Launch OMA (min)	-14.8(33.1)	dBm(μW)
Transmitter eye mask definition{X1, X2, X3, Y1, Y2, Y3, Y4}	{0.18, 0.29, 0.35, 0.35, 0.38, 0.4, 0.55}	UI
Transmitter and dispersion penalty (max)	4.5	dB
Decision timing offsets for transmitter and dispersion penalty (min)	±1.6	ns

Table 7.31. Transmitter characteristics for 100 Base-LX10

a) The nominal transmitter type is not intended to be a requirement on the source type, and any transmitter meeting the transmitter characteristics specified may be substituted for the nominal transmitter type.

b) The great majority of the transmitted spectrum must fall within the operating wavelength range, see 58.7.2 in 802.3ah.

c) The RIN12OMA recommendation is informative not mandatory.

Description	Type B1.1, B1.3 SMF	Unit
Average received power (a) (max)	-8	dBm
Receiver sensitivity (max)	-25	dBm
Receiver sensitivity as OMA (max)	-24.8(3.3)	dBm(µW)
Receiver reflectance (b) (max)	-12	dB
Stressed receiver sensitivity (c)	-20.1	dBm
Stressed receiver sensitivity as OMA (max)	-19.9(10.2)	dBm(µW)
Vertical eye-closure penalty (min)	3.7	dB
Stressed eye jitter (min)	0.25	UI pk-pk
Jitter corner frequency	20	kHz
Sinusoidal jitter limits for stressed receiver conformance test (min, max)	0.05, 0.15	UI
Signal detect threshold (min)	-45	dBm

Table 7.32. Receiver characteristics for 100 Base -LX10

a) The receiver is able to tolerate, without damage, continuous exposure to an optical input signal having a power level equal to the average received power (max) plus at least 1 dB.

b) The stressed receiver sensitivity is optional.

c) Vertical eye closure penalty and the jitter specifications are test conditions for measuring stressed receiver sensitivity. They are not required characteristics of the receiver.

Detail	Compliance to Specification
The format of the signal	802.3-2002
Signal line rate	802.3ah-2004 ch.58.3.1
Operating wavelength	802.3ah-2004 ch.58.3.1
Optical output jitter	802.3ah-2004 ch.58.3.1
Optical spectrum	802.3ah-2004 ch.58.3.1
Optical output power	802.3ah-2004 ch.58.3.1
Optical eye diagram	802.3ah-2004 ch.58.3.1
Optical extinction ratio	802.3ah-2004 ch.58.3.1
Optical return loss	802.3ah-2004 ch.58.3.1
Launch OMA	802.3ah-2004 ch.58.3.1
Receiver overload	802.3ah-2004 ch.58.3.2
Receiver sensitivity	802.3ah-2004 ch.58.3.2
Optical input jitter	802.3ah-2004 ch.58.3.2
Receiver reflectance	802.3ah-2004 ch.58.3.2
Signal detect threshold	802.3ah-2004 ch.58.3.2
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Reflectance of receiver according to specification	802.3ah-2004 ch.58.3.1

Table 7.33. 100 Base-LX10 physical compliance

7.18 100 BASE-ZX

This is an optical FE long haul interface. The definitions of optical parameters and reference points S and R refer to ITU-T G.957. Reference point S means transmit direction while R is the receive direction of the fiber.

Parameter	Value
Modulation rate on optical line	125 000 kbps
Wavelength range	1480- 1580 nm
Transmitter at reference point S	
Source type	SLM
Spectral characteristics (max. RMS width)	NA
Maximum -20 dB width	1
Minimum side mode suppression ratio	30
Mean launched power (max.)	0 dBm
Mean launched power (min.)	-5 dBm
Minimum extinction ratio	10 dB
Optical path between S and R	
Attenuation range	10 - 28 dB
Maximum tolerable dispersion	NA
Minimum optical return loss	20
Maximum discrete reflectance between S and R	-25
Receiver at reference point R	
Minimum sensitivity (BER < 1 in 1010)	-34 dBm
Minimum overload	-10 dBm
Maximum optical path penalty	1 dB
Maximum reflectance at R	-25 dB

Table 7.34. Optical budget "100 Base-ZX" interface

Detail	Compliance to Specification
The type of optical fiber	G.652 03/2003
The format of the signal	G.707 10/2000
RX pull-in and hold range	G.783 10/2000 ch 9.3.1.2
Optical output jitter	G.813 10/2000
Optical input jitter	G.825 03/2000 ch 6.1.2.1
Optical spectrum	G.957 06/1999 Table 2
Optical output power	G.957 06/1999 Table 2
Optical eye diagram	G.957 06/1999 ch 6.2.5
Optical extinction ratio	G.957 06/1999 Table 2
Receiver sensitivity	G.957 06/1999 Table 2
Receiver overload	G.957 06/1999 Table 2
Reflectance of receiver	G.957 06/1999 Table 2
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001 G.958 11/1994 ch 9.7 G.664 03/2003
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Optical Path Penalty according to specification	G.957 06/1999 Table 2
Reflectance of receiver according to specification	G.957 06/1999 Table 2

Table 7.35. "100 Base-ZX" physical compliance

7.19 1000 BASE-SX

This is a Gigabit Ethernet (GE) interface that meets the 1000 Base-SX specifications in IEEE 802.3. It is an optical short haul interface based on multi-mode fiber.

fiber type	Modal bandwidth @ 1300 nm (min. overfilled launch) (MHz · km)	Minimum range (meters)
62.5 µm MMF	160	2 to 220
62.5 µm MMF	200	2 to 275
50 µm MMF	400	2 to 500
50 µm MMF	500	2 to 550
10 µm SMF	N/A	Not supported

Table 7.36. Operating range for 1000 Base-SX over each optical fiber type

Description	62.5 µm MMF 50 µm MMF	Unit
Transmitter type	Shortwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	770 to 860	nm
Trise/Tfall (max; 20%-80%; > 830 nm)	0.26	ns
Trise/Tfall (max; 20%-80%; < 830 nm)	0.21	ns
RMS spectral width (max)	0.85	nm
Average launch power (max)	-3,5 [a]	dBm
Average launch power (min)	-11.5	dBm
Average launch power of OFF transmitter (max) [b]	-30	dBm
Extinction ratio (min)	9	dB
RIN (max)	-117	dB/Hz
Coupled Power Ratio (CPR) [c]	9 < CPR	dB

Table 7.37. Transmitter characteristic for 1000 Base-SX

a) The 1000BASE-SX launch power is the lesser of the class 1 safety limit as defined by 802.3 38.7.2 or the average receive power (max) defined by 802.3 Table 38-4.

b) Examples of an OFF transmitter are: no power supplied to the PMD, laser shutdown for safety conditions, activation of a "transmit disable" or other optional module laser shut down conditions. During all conditions when the PMA is powered, the AC signal (data) into the transmit port will be valid encoded 8B/10B patterns (this is a requirement of the PCS layers) except for short durations during system power-on-reset or diagnostics when the PMA is placed in a loopback mode.

c) Radial overfilled launches as described in 802.3 38A.2, while they may meet CPR ranges, should be avoided.

Description	62.5 µm	50 µm	Unit
Signaling speed (range)	1.25 ± 100 ppm		GBd
Wavelength (range)	770 to 860		nm
Average receive power (max)	0		dBm
Receive sensitivity	-17		dBm
Return loss (min)	12		dB
Stressed receive sensitivity	-12.5	-13.5	dBm
Vertical eye-closure penalty	2.60	2.20	dB
Receive electrical 3 dB uppercutoff frequency (max)	1500		MHz

Table 7.38. Receiver characteristic for 1000 Base-SX

Detail	Compliance to Specification
Transmitter type	802.3 2002 ch 38.3.1
Transmitter speed	802.3 2002 ch 38.3.1
Wavelength	802.3 2002 ch 38.3.1
Trise and Tfall	802.3 2002 ch 38.3.1
Spectrum	802.3 2002 ch 38.3.1
Output power	802.3 2002 ch 38.3.1
Extinction ratio	802.3 2002 ch 38.3.1
Pulse mask	802.3 2002 ch 38.6.5
Receiver speed	802.3 2002 ch 38.3.2
Wavelength	802.3 2002 ch 38.3.2
Maximum input power	802.3 2002 ch 38.3.2
Receive sensitivity	802.3 2002 ch 38.3.2
Return loss	802.3 2002 ch 38.3.2
Stressed receive sensitivity	802.3 2002 ch 38.3.2
Jitter	802.3 2002 ch 38.5
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5

Table 7.39. 1000 Base-SX physical compliance

7.20 1000 BASE-LX

This is a Gigabit Ethernet (GE) interface that meets the 1000 Base-LX specification in IEEE 802.3. It is an optical long haul interface based on single-mode fiber.

fiber type	Modal bandwidth @ 1300 nm (min. overfilled launch) (MHz · km)	Minimum range (meters)
62.5 µm MMF	500	2 to 550
50 µm MMF	400	2 to 550
50 µm MMF	500	2 to 550
10 µm SMF	N/A	2 to 5000

Table 117 Operating range for 1000 Base-LX over each optical fiber type

Description	62.5 µm MMF	50 µm MMF	10 µm SMF	Unit
Transmitter type	Longwave Laser			
Signaling speed (range)	1.25 ± 100 ppm			GBd
Wavelength (range)	1270 to 1355			nm
Trise/Tfall (max, 20-80% response time)	0.26			ns
RMS spectral width (max)	4			nm
Average launch power (max)	-3			dBm
Average launch power (min)	-11.5	-11.5	-11.0	dBm
Average launch power of OFF transmitter (max)	-30			dBm
Extinction ratio (min)	9			dB
RIN (max)	-120			dB/Hz
Coupled Power Ratio (CPR) (a)	28 < CPR< 40	12 < CPR < 20	N/A	dB

Table 7.40. Transmitter characteristic for 1000 Base-LX

a) Due to the dual media (single-mode and multimode) support of the LX transmitter, fulfilment of this specification requires a single-mode fiber offset-launch mode-conditioning patch cord described in 802.3 chapter 38.11.4 for MMF operation. This patch cord is not used for single-mode operation.

Description	Value	Unit
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1270 to 1355	nm
Average receive power (max)	-3	dBm
Receive sensitivity	-19	dBm
Return loss (min)	12	dB
Stressed receive sensitivity	-14.4	dBm
Vertical eye-closure penalty	2.60	dB
Receive electrical 3 dB uppercutoff frequency (max)	1500	MHz

Table 7.41. Receiver characteristic for 1000 Base-LX

Detail	Compliance to Specification
Transmitter type	802.3 2002 ch 38.4.1
Transmitter speed	802.3 2002 ch 38.4.1
Wavelength	802.3 2002 ch 38.4.1
Trise and Tfall	802.3 2002 ch 38.4.1
Spectrum	802.3 2002 ch 38.4.1
Output power	802.3 2002 ch 38.4.1
Extinction ratio	802.3 2002 ch 38.4.1
Pulse mask	802.3 2002 ch 38.6.5
Receiver speed	802.3 2002 ch 38.4.2
Wavelength	802.3 2002 ch 38.4.2
Maximum input power	802.3 2002 ch 38.4.2
Receive sensitivity	802.3 2002 ch 38.4.2
Return loss	802.3 2002 ch 38.4.2
Stressed receive sensitivity	802.3 2002 ch 38.4.2
Jitter	802.3 2002 ch 38.5
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001
LOS is detected between minimum RX sensitivity and -45 dBm.	
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5

Table 7.42. 1000 Base-LX physical compliance

7.21 1000 BASE-LX10

This is a Gigabit Ethernet (GE) interface that meets the 1000 Base-LX10 specification in IEEE 802.3ah. It is an optical long haul interface based on single-mode fiber.

fiber type	Modal bandwidth @ 1300 nm (min. overfilled launch) (MHz · km)	Minimum range (meters)
62.5 µm MMF	500	2 to 550
50 µm MMF	500	2 to 550
10 µm SMF	N/A	2 to 10000

Table 7.43. Operating range for 1000 Base-LX10 over each optical fiber type

Description	62.5 µm MMF	50 µm MMF	10 µm SMF	Unit
Transmitter type	Longwave Laser			
Signaling speed (range)	1.25 ± 100 ppm			GBd
Wavelength (range)	1260 to 1360			nm
Trise/Tfall (max, 20-80% response time)	0.30			ns
RMS spectral width (max)	See Table 59-4 in 802.3ah			nm
Average launch power (max)	-3			dBm
Average launch power (min)	-11	-11	-9	dBm
Average launch power of OFF transmitter (max)	-45			dBm
Extinction ratio (min)	6			dB
$RIN_{12}OMA$ (max)	-113			dB/Hz
Optical return loss tolerance (max)	12			dB
Launch OMA (min)	-10.2(100)	-10.2(100)	-8.7(130)	dBm(uW)
Transmitter eye mask definition {X1, X2, Y1, Y2, Y3}	0.22, 0.375, 0.20, 0.20, 0.30			UI
Decision timing offsets for transmitter and dispersion penalty (min)	±80			ps
Transmitter reflectance (max)	-6			dB
Transmitter and dispersion penalty, TDP (max)	3.5		3.3	dB
Differential delay, reference receiver for TDP (min)(c)	367		NA	ps

Table 7.44. Transmitter characteristic for 1000 Base-LX10

a) The nominal device type is not intended to be a requirement on the source type, and any device meeting the transmitter characteristics specified may be substituted for the nominal device type.

b) The great majority of the transmitted spectrum must fall within the operating wavelength range. The allowable range of central wavelengths is narrower than the operating wavelength range by the actual RMS spectral width at each extreme.

c) Delay is calculated as Td=L/(3.BWf) where BWf is defined to -3 dB (optical). 1000BASE-LX is rated for 550 m of 500 MHz.km fiber while 1000BASE-LX also covered 550 m of 400 MHz.km fiber, but this is now seen as a historical bandwidth requirement.

Description	Value	Unit
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1260 to 1360	nm
Average receive power (max)	-3	dBm
Receive sensitivity	-19.5	dBm
Return loss (min)	12	dB
Receiver sensitivity as OMA (max)	-18.7(13.4)	dBm(µW)
Bit error ratio (max)	10-12	
Receiver reflectance (max)	-12	dB
Stressed receive sensitivity	-15.4	dBm
Stressed receiver sensitivity as OMA (max)	-14.6(35)	dBm(µW)
Vertical eye-closure penalty (min)	3.60	dB
Receive electrical 3 dB uppercutoff frequency (max)	1500	MHz
Signal detect threshold (min)	-45	dBm
Stressed eye jitter (min)	0.3	UI pk-pk
Jitter corner frequency	637	kHz
Sinusoidal jitter limits for stressed receiver conformance test (min, max)	0.05, 0.15	UI

Table 7.45. Receiver characteristic for 1000 Base-LX

Detail	Compliance to Specification
Transmitter type	802.3ah-02 ch 59.3.1
Transmitter speed	802.3 2002 ch 59.3.1
Wavelength	802.3 2002 ch 59.3.1
Trise and Tfall	802.3 2002 ch 59.3.1
Spectrum	802.3 2002 ch 59.3.1
Output power	802.3 2002 ch 59.3.1
Extinction ratio	802.3 2002 ch 59.3.1
Pulse mask	802.3 2002 ch 59.3.1
Receiver speed	802.3 2002 ch 59.3.2
Wavelength	802.3 2002 ch 59.3.2
Maximum input power	802.3 2002 ch 59.3.2
Receive sensitivity	802.3 2002 ch 59.3.2
Return loss	802.3 2002 ch 59.3.2
Stressed receive sensitivity	802.3 2002 ch 59.3.2
Jitter	802.3 2002 ch 59.3.2
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001
Signal detect threshold	802.3ah-2004 ch.59.3.2
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Reflectance of receiver according to specification	802.3ah-2004 ch.59.3.1

Table 7.46. 1000 Base-LX physical compliance

7.22 1000 BASE-ZX

This is a Gigabit Ethernet (GE) interface that meets the 1000 Base-ZX specification in IEEE 802.3. This is an optical ultra long haul interface based on single-mode fiber.

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1540 to 1570	nm
Trise/Tfall (max, 20-80% response time)	0.26	ns
RMS spectral width (max)	1	nm
Average launch power (max)	2	dBm
Average launch power (min)	-3	dBm
Average launch power of OFF transmitter (max)	-45	dBm
Extinction ratio (min)	9	dB

Table 7.47. Transmitter characteristic for 1000 Base-ZX

Description	Value	Unit
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1540 to 1570	nm
Average receive power (max)	-3	dBm
Receive sensitivity	-24	dBm
Return loss (min)	12	dB

Table 7.48. Receiver characteristic for 1000 Base-ZX

Detail	Compliance to Specification
Pulse mask	802.3 2002 ch 38.6.5
Jitter	802.3 2002 ch 38.5
Optical safety CLASS I	60825-1 08/2001
Labelled according to specification	60825-1 08/2001
Safety requirements	60825-1 08/2001 60825-2 08/2001
Signal detect threshold	802.3ah-2004 ch.59.3.2
Supports input level meter with a tolerance of 3 dB	SFF-8472 Rev. 9.5
Reflectance of receiver according to specification	802.3ah-2004 ch.59.3.1

Table 7.49. 1000 Base-ZX physical compliance requirements

7.23 1000 BASE-TX

This is a 1000 Base-TX Ethernet interface according to the IEEE 802.3 specification. Note that the 1000 Base-TX is based on an SFP module and uses the same module slots as the optical GE modules.

The connectors are RJ-45 connectors with the following pin-out:

Pin	Signal
1	DA+
2	DA-
3	DB+
4	DC+
5	DC-
6	DB-
7	DD+
8	DD-

Table 7.50. Pin-out 1000 Base-TX port

Detail	Compliance to Specification
Supports STP-5 cabling	802.3 2002 ch 40.7.1
Minimum 100m of cable	802.3 2002 ch 25.4.6
Peak differential output voltage and level accuracy	802.3 2002 ch 40.6.1.2.1
Maximum output droop	802.3 2002 ch 40.6.1.2.2
Differential output templates	802.3 2002 ch 40.6.1.2.3
Transmitter distortion	802.3 2002 ch 40.6.1.2.4

Detail	Compliance to Specification
Transmitter timing jitter	802.3 2002 ch 40.6.1.2.5
Transmit clock frequency	802.3 2002 ch 40.6.1.2.6
Receiver differential input signals	802.3 2002 ch 40.6.1.3.1
Receiver frequency tolerance	802.3 2002 ch 40.6.1.3.2
Common-mode noise rejection	802.3 2002 ch 40.6.1.3.3
Alien Crosstalk noise rejection	802.3 2002 ch 40.6.1.3.4
Return loss	802.3 2002 ch 40.8.3.1
MDI impedance balance	802.3 2002 ch 40.8.3.2
MDI common-mode output voltage	802.3 2002 ch 40.8.3.3
MDI fault tolerance	802.3 2002 ch 40.8.3.4
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998
Surge over voltage at unshielded balanced signal lines	K.41 05/1998

Table 7.51. 1000 Base-TX physical compliance requirements

7.24 E1

This is a 2Mbps E1 interface according to ITU-T G.703, 120ohm differential pair. The connector is a RJ-45 connector with the following pin-out:

Pin	Signal
1	OUT+
2	OUT-
3	GND
4	IN+
5	IN-
6	Screen (a)
7	NC
8	NC

Table 7.52. Pin-out E1 interface

a) Pin 6 is always AC connected to ground. The outer screen is always direct connected to ground.

Table 7.53. E1 physical compliance requirements

Detail	Compliance to Specification
Frequency tolerance	G.703 11/01 ch.9.1
HDB3 signal coding	G.703 11/01 ch.9.1
Output pulse shapes for both 75 and 120 ohm	G.703 11/01 ch.9.2
Output return loss	G.703 11/01 ch.9.2
Cable attenuation	G.703 11/01 ch.9.3
Input return loss	G.703 11/01 ch.9.3
Interfering signal	G.703 11/01 ch.9.3
Grounded input and output shield	G.703 11/01 ch.9.4
120 ohm pinout	EN 300246 10/93 ch. 5.1.1
Impedance of interface	EN 300418 V1.2.1 ch.4.2.2.3
Impedance towards ground for output	EN 300418 V1.2.1ch 4.2.1.4
Tolerable longitudinal voltage	EN 300418 V1.2.1ch 4.2.2.5
Impedance towards ground for input	EN 300418 V1.2.1ch. 4.2.2.6
Input jitter and wander	G.823 03/00 ch 7.1.2
Input jitter	EN 300247 V1.2.2 ch. 4.1.7.1
Output jitter in the absence of input jitter	G.783 10/00 ch.15.2.3.1
Output combined jitter	G.783 10/00 ch. 15.2.3.3
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998

7.25 MULTI INTERFACE 63XE1

This is a high density 160 pin LFH connector from Molex.

Two connectors are used:

- The lower connector with 32 interfaces
- The upper connector with 31 interfaces

Lower connector

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	IN29-	41	IN2-	81	IN31-	121	IN4-
2	IN29+	42	IN2+	82	IN31+	122	IN4+
3	GND	43	GND	83	GND	123	GND
4	OUT29-	44	OUT2-	84	OUT31-	124	OUT4-
5	OUT29+	45	OUT2+	85	OUT31+	125	OUT4+
6	IN25-	46	IN6-	86	IN27-	126	IN8-
7	IN25+	47	IN6+	87	IN27+	127	IN8+
8	GND	48	GND	88	GND	128	GND
9	OUT25-	49	OUT6-	89	OUT27-	129	OUT8-
10	OUT25+	50	OUT6+	90	OUT27+	130	OUT8+
11	IN21-	51	IN10-	91	IN23-	131	IN12-
12	IN21+	52	IN10+	92	IN23+	132	IN12+
13	GND	53	GND	93	GND	133	GND
14	OUT21-	54	OUT10-	94	OUT23-	134	OUT12-
15	OUT21+	55	OUT10+	95	OUT23+	135	OUT12+
16	IN17-	56	IN14-	96	IN19-	136	IN16-
17	IN17+	57	IN14+	97	IN19+	137	IN16+
18	GND	58	GND	98	GND	138	GND
19	OUT17-	59	OUT14-	99	OUT19-	139	OUT16-
20	OUT17+	60	OUT14+	100	OUT19+	140	OUT16+
21	IN13-	61	IN18-	101	IN15-	141	IN20-
22	IN13+	62	IN18+	102	IN15+	142	IN20+
23	GND	63	GND	103	GND	143	GND
24	OUT13-	64	OUT18-	104	OUT15-	144	OUT20-
25	OUT13+	65	OUT18+	105	OUT15+	145	OUT20+
26	IN9-	66	IN22-	106	IN11-	146	IN24-
27	IN9+	67	IN22+	107	IN11+	147	IN24+
28	GND	68	GND	108	GND	148	GND
29	OUT9-	69	OUT22-	109	OUT11-	149	OUT24-
30	OUT9+	70	OUT22+	110	OUT11+	150	OUT24+
31	IN5-	71	IN26-	111	IN7-	151	IN28-

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
32	IN5+	72	IN26+	112	IN7+	152	IN28+
33	GND	73	GND	113	GND	153	GND
34	OUT5-	74	OUT26-	114	OUT7-	154	OUT28-
35	OUT5+	75	OUT26+	115	OUT7+	155	OUT28+
36	IN1-	76	IN30-	116	IN3-	156	IN32-
37	IN1+	77	IN30+	117	IN3+	157	IN32+
38	GND	78	GND	118	GND	158	GND
39	OUT1-	79	OUT30-	119	OUT3-	159	OUT32-
40	OUT1+	80	OUT30+	120	OUT3+	160	OUT32+

Table 7.54. Pin-out of lower multi-interface connector

Upper connector

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	IN61-	41	IN34-	81	IN63-	121	IN36-
2	IN61+	42	IN34+	82	IN63+	122	IN36+
3	GND	43	GND	83	GND	123	GND
4	OUT61-	44	OUT34-	84	OUT63-	124	OUT36-
5	OUT61+	45	OUT34+	85	OUT63+	125	OUT36+
6	IN57-	46	IN38-	86	IN59-	126	IN40-
7	IN57+	47	IN38+	87	IN59+	127	IN40+
8	GND	48	GND	88	GND	128	GND
9	OUT57-	49	OUT38-	89	OUT59-	129	OUT40-
10	OUT57+	50	OUT38+	90	OUT59+	130	OUT40+
11	IN53-	51	IN42-	91	IN55-	131	IN44-
12	IN53+	52	IN42+	92	IN55+	132	IN44+
13	GND	53	GND	93	GND	133	GND
14	OUT53-	54	OUT42-	94	OUT55-	134	OUT44-
15	OUT53+	55	OUT42+	95	OUT55+	135	OUT44+
16	IN49-	56	IN46-	96	IN51-	136	IN48-
17	IN49+	57	IN46+	97	IN51+	137	IN48+
18	GND	58	GND	98	GND	138	GND
19	OUT49-	59	OUT46-	99	OUT51-	139	OUT48-
20	OUT49+	60	OUT46+	100	OUT51+	140	OUT48+
21	IN45-	61	IN50-	101	IN47-	141	IN52-
22	IN45+	62	IN50+	102	IN47+	142	IN52+
23	GND	63	GND	103	GND	143	GND
24	OUT45-	64	OUT50-	104	OUT47-	144	OUT52-
25	OUT45+	65	OUT50+	105	OUT47+	145	OUT52+
26	IN41-	66	IN54-	106	IN43-	146	IN56-

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
27	IN41+	67	IN54+	107	IN43+	147	IN56+
28	GND	68	GND	108	GND	148	GND
29	OUT41-	69	OUT54-	109	OUT43-	149	OUT56-
30	OUT41+	70	OUT54+	110	OUT43+	150	OUT56+
31	IN37-	71	IN58-	111	IN39-	151	IN60-
32	IN37+	72	IN58+	112	IN39+	152	IN60+
33	GND	73	GND	113	GND	153	GND
34	OUT37-	74	OUT58-	114	OUT39-	154	OUT60-
35	OUT37+	75	OUT58+	115	OUT39+	155	OUT60+
36	IN33-	76	IN62-	116	IN35-	156	
37	IN33+	77	IN62+	117	IN35+	157	
38	GND	78	GND	118	GND	158	GND
39	OUT33-	79	OUT62-	119	OUT35-	159	
40	OUT33+	80	OUT62+	120	OUT35+	160	

Table 7.55. Pin-out of upper multi-interface connector

Detail	Compliance to Specification
Frequency tolerance	G.703 11/01 ch.9.1
HDB3 signal coding	G.703 11/01 ch.9.1
Output pulse shapes for both 75 and 120 ohm	G.703 11/01 ch.9.2
Output return loss	G.703 11/01 ch.9.2
Cable attenuation	G.703 11/01 ch.9.3
Input return loss	G.703 11/01 ch.9.3
Interfering signal	G.703 11/01 ch.9.3
Grounded input and output shield	G.703 11/01 ch.9.4
Impedance of interface	EN 300418 V1.2.1 ch.4.2.2.3
Impedance towards ground for output	EN 300418 V1.2.1ch 4.2.1.4
Tolerable longitudinal voltage	EN 300418 V1.2.1ch 4.2.2.5
Impedance towards ground for input	EN 300418 V1.2.1ch. 4.2.2.6
Input jitter and wander	G.823 03/00 ch 7.1.2
Input jitter	EN 300247 V1.2.2 ch. 4.1.7.1
Output jitter in the absence of input jitter	G.783 10/00 ch.15.2.3.1
Output combined jitter	G.783 10/00 ch. 15.2.3.3
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998

Table 7.56. 63xE1 physical compliance requirements

7.26 E3

This is a 34Mbps E3 according to ITU-T G.703, 75 ohm coaxial interface.

Detail	Compliance to Specification
Frequency tolerance for E3	G.703 11/01 ch.11.1
HDB3 signal coding	G.703 11/01 ch.11.1
Output pulse shapes for 75 ohm for E3	G.703 11/01 ch.11.2
Output return loss for E3	G.703 11/01 ch.11.2
Cable attenuation for E3	G.703 11/01 ch.11.3
Input return loss for E3	G.703 11/01 ch.113
Interfering signal for E3	G.703 11/01 ch.11.3
Grounded input and output shield for E3	G.703 11/01 ch.11.4
Input jitter and wander for E3	G.823 03/00 ch 7.1.4
Output jitter in the absence of input jitter for E3	G.783 10/00 ch.15.2.3.1
Output combined jitter for E3	G.783 10/00 ch. 15.2.3.3
The screen on the input and on the output connector is always DC coupled to ground.	
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998

Table 7.57. E3 physical compliance requirement

7.27 T3

This is a 45Mbps T3 75 ohm coaxial interface according to ITU-T G.703.

Detail	Compliance to Specification
Frequency tolerance for T3	G.703 11/01 ch.8
B3ZS signal coding	G.703 11/01 ch.8
Output pulse shapes for 75 ohm for T3	G.703 11/01 ch.8
Power level for T3	G.703 11/01 ch.8
Pulse imbalance for T3	G.703 11/01 ch.8
No DC power for T3	G.703 11/01 ch.8
Cable attenuation for T3 (0-137.2m of AT&T 728A cable)	GR-253 09/00 ch 2.1.1.1
Input jitter and wander for T3	G.824 03/00 ch 7.2.4
Output jitter for T3	G.824 03/00 ch 5.1
Output jitter in the absence of input jitter for T3	G.783 10/00 ch.15.2.3.1
Output combined jitter for T3	G.783 10/00 ch. 15.2.3.3
The screen on the input and on the output connector is always DC coupled to ground.	
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998

Table 7.58. T3 physical compliance requirements

7.28 SYNCHRONISATION

The interface can be either a 2 Mbps (E1) interface or a 2.048 MHz clock interface according to ITU-T G.703, 120ohm differential pair.

The connector is a RJ-45 connector with the following pin-out:

Pin	Signal
1	OUT+
2	OUT-
3	GND
4	IN+
5	IN-
6	Screen (a)
7	NC
8	NC

Table 7.59. Pin-out synchronisation interface

a) Pin 6 is always AC connected to ground. The outer screen is always direct connected to ground.

Detail	Compliance to Specification
Frequency tolerance	G.703 11/01 ch.13.2
HDB3 signal coding for E1 mode	G.703 11/01 ch.9.1
Output pulse shapes for both 75 and 120 ohm (E1)	G.703 11/01 ch.9.2
Output pulse shapes for both 75 and 120 ohm (2.048 MHz)	G.703 11/01 ch.13.2
Maximum output voltage (2.048 MHz)	G.703 11/01 ch.13.2
Minimum output voltage (2.048 MHz)	G.703 11/01 ch.13.2
Output return loss	G.703 11/01 ch.9.2
Cable attenuation	G.703 11/01 ch.13.3
Input return loss	G.703 11/01 ch.13.3
Interfering signal	G.703 11/01 ch.9.3
Grounded input and output shield	G.703 11/01 ch.13.4
120 ohm pinout	EN 300246 10/93 ch. 5.1.1
Impedance of interface	EN 300418 V1.2.1 ch.4.2.2.3
Impedance towards ground for output	EN 300418 V1.2.1ch 4.2.1.4
Tolerable longitudinal voltage	EN 300418 V1.2.1ch 4.2.2.5
Impedance towards ground for input	EN 300418 V1.2.1ch. 4.2.2.6
Input jitter and wander	G.823 03/00 ch 7.1.2 G.823 03/00 ch 6.1
Output jitter	G.813 08/96 ch 7.1
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998

Table 7.60. Synchronisation physical compliance requirements

7.29 POWER

The -48V DC supply input is provided via a 3-pin power DSUB connector, with the following pin-out:

Pin	Signal
1	0V
2	-Vbatt
3	GND

Table 7.61. Pin-out DC connector

Detail	Compliance to Specification
20A fuse	
Maximum power dissipation is 450W	
Meets safety requirements for a SELV voltage when using -48V power	IEC 60950 10/2001
Meets safety requirements for a TNV-2 voltage when using -60V power	IEC 60950 10/2001
Meet nominal voltage of -48V	300132 V2.1.2 09/2003 ch 4.1
Normal service voltage range -48V	300132 V2.1.2 09/2003 ch 4.2
Abnormal service voltage range -48V	300132 V2.1.2 09/2003 ch 4.3.1
Recovery from abnormal service voltage range	300132 V2.1.2 09/2003 ch 4.3.2
Voltage transients	300132 V2.1.2 09/2003 ch 4.3.3
Recovery from voltage transients	300132 V2.1.2 09/2003 ch 4.3.4
Voltage changes due to regulation of the power supply	300132 V2.1.2 09/2003 ch 4.4
Supply protection	300132 V2.1.2 09/2003 ch 4.5
Maximum current drain following abnormal service	300132 V2.1.2 09/2003 ch 4.6
Surge currents (inrush current)	300132 V2.1.2 09/2003 ch 4.7
Immunity to narrowband noise	300132 V2.1.2 09/2003 ch 4.8.1
Immunity to wideband noise	300132 V2.1.2 09/2003 ch 4.8.2
Emission of narrowband noise	300132 V2.1.2 09/2003 ch 4.9.1
Emission of wideband noise	300132 V2.1.2 09/2003 ch 4.9.2
Meet nominal voltage of -60V	300132 V2.1.2 09/2003 Annex A
Normal service voltage range -60V	300132 V2.1.2 09/2003 Annex A
Abnormal service voltage range -60V	300132 V2.1.2 09/2003 Annex A
Will raise an alarm when input voltage is less than -37.5V or more than -57V when configured for an -48V battery	
Will raise an alarm when the input voltage is less than -50V or more than -72V when configured for an -60V battery	
Grounding and bonding	300253 V2.1.1 04/2002
Emission DC power port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.3
Immunity DC power port, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.5
Immunity DC power port, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.5
Surge over voltage at DC power port	K.41 05/1998

Table 7.62. Power supply physical compliance requirements

7.30 AUX

This is a 2Mbps E1 interface according to ITU-T G.703, 120ohm differential pair.

The connector is a RJ-45 connector, with the following pin-out:

Pin	Signal
1	OUT+
2	OUT-
3	GND
4	IN+
5	IN-
6	Screen (a)
7	NC
8	NC

Table 7.63. Pin-out E1 interface

a) Pin 6 is always AC connected to ground. The outer screen is always direct connected to ground.

Detail	Compliance to Specification
Frequency tolerance	G.703 11/01 ch.9.1
HDB3 signal coding	G.703 11/01 ch.9.1
Output pulse shapes for both 75 and 120 ohm	G.703 11/01 ch.9.2
Output return loss	G.703 11/01 ch.9.2
Cable attenuation	G.703 11/01 ch.9.3
Input return loss	G.703 11/01 ch.9.3
Interfering signal	G.703 11/01 ch.9.3
Grounded input and output shield	G.703 11/01 ch.9.4
120 ohm pinout	EN 300246 10/93 ch. 5.1.1
Impedance of interface	EN 300418 V1.2.1 ch.4.2.2.3
Impedance towards ground for output	EN 300418 V1.2.1ch 4.2.1.4
Tolerable longitudinal voltage	EN 300418 V1.2.1ch 4.2.2.5
Impedance towards ground for input	EN 300418 V1.2.1ch. 4.2.2.6
Input jitter and wander	G.823 03/00 ch 7.1.2
Input jitter	EN 300247 V1.2.2 ch. 4.1.7.1
Output jitter in the absence of input jitter	G.783 10/00 ch.15.2.3.1
Output combined jitter	G.783 10/00 ch. 15.2.3.3
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3
Surge over voltage at shielded signal lines	K.41 05/1998

Table 7.64. Auxiliary physical compliance requirements

7.31 CLI

The AXXMETRO offers a VT-100 interface for connection of a Command Line Interface (CLI). The RS232 interface is provided via a RJ-45 connector and a 9-pin DSUB with the following pin-outs:

Pin	Signal
1	GND
2	TxD
3	RxD
4	DB-TxD (only used for debug purposes)
5	NC
6	RTS
7	DB_RxD (only used for debug purposes)
8	NC

Table 7.65. Pin-out VT-100 connector

Detail	Compliance to Specification
The CLI interface runs at a data rate of 19.200 kbaud+/- 200ppm	
The CLI interface supports 8 bit asynchronous transmission	
The CLI interface supports 1 start bit and 1 stop bit	
The CLI interface emulates a VT-100 terminal	
The debug interface runs at a rate of 19200 baud	
The debug interface supports 8 bit asynchronous transmission	
The debug interface supports 1 start bit and 1 stop bit	
The electrical interface	V.28 03/93
Load impedance	V.28 03/93 ch 3
Open circuit voltage	V.28 03/93 ch 3
Shunt capacitance	V.28 03/93 ch 3
Output voltage	V.28 03/93 ch 4
Open circuit and short circuit	V.28 03/93 ch 4
Driving capacitive loads	V.28 03/93 ch 4
Voltage levels ON	V.28 03/93 ch 5
Voltage levels OFF	V.28 03/93 ch 5
Signal characteristic	V.28 03/93 ch 6 and annex A

Table 7.66. CLI interface physical compliance requirements

7.32 ALARM

This alarm interface supports both alarm inputs and alarm outputs.

The connector is a 15 pins DSUB connector with the following pin-out:

Pin	Signal
1	Alarm input 1
2	Alarm input 2
3	Alarm input 3
4	Alarm input 4
5	Alarm input 5
6	Alarm input 6
7	Alarm input 7
8	Alarm input 8
9	Alarm input return (1-8)
10	Alarm output 1
11	Alarm output 1 return
12	Alarm output 2
13	Alarm output 2 return
14	Alarm output 3
15	Alarm output 3 return

9-pin DSUB pinout:

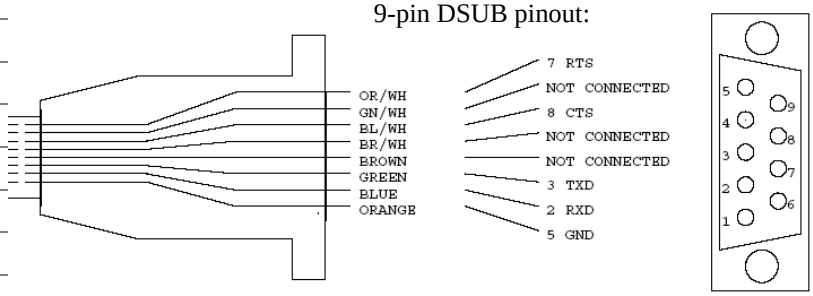


Table 7.67. Pin-out alarm connector

Electrical parameters alarm input

Parameter	Value
Nominal open contact voltage	+3.3 V
Nominal closed contact current	1 mA
Max. closed contact resistance	0.8 kohm
Min. open contact resistance	10 kohm
Common return to earth	0 V (No isolation)

Table 7.68. Electrical specification for alarm input

Electrical parameters alarm output

Parameter	Value
Maximum load bias referred to common return	+/-75 V
Maximum load current	50 mA
Common return to earth	+/-250 V
Maximum contact resistance	50 ohm
Switching time	10 ms

Table 7.69. Electrical specification for alarm output

Requirements for alarm interface

Detail	Compliance to Specification
The physical connector is a female 15 pin DSUB	
Minimum 8 alarm inputs	
Minimum 3 alarm outputs	
Individually enable and disable alarm inputs	
Individually set alarm to active high or active low	
Alarm output 1 is active without power	
Alarm outputs 2 and 3 are not active without power	
Alarm outputs may be configured to represent different alarms in AXXMETRO	
Default configuration of Alarm output 1 is Critical alarm	
Default configuration of Alarm output 2 is Major alarm	
Default configuration of Alarm output 3 is Minor alarm	
Emission telecommunication port, Conducted emission	300386 V1.3.2 12/2002 ch 7.1.4
Immunity ports for indoor signal lines, Fast transients	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoor signal lines, Surges	300386 V1.3.2 12/2002 ch 7.2.2.3
Immunity ports for indoors signal lines, Radio frequency conducted continuous	300386 V1.3.2 12/2002 ch 7.2.2.3

Table 7.70. Alarm interface physical compliance

[7.33]SFP

[7.33.1] Interface modules provisioning

Interface modules are pluggable port interfaces. There are several types of interface modules: SFP, XFP, GBIC etc. This network element release supports only SFP's.

Interface modules must be provisioned by the management system. Only one type of interface module is supported by one module (card) type and is therefore implicitly defined. The management system provisions the interface modules attributes. Attribute values for SDH port interface modules are S.x.1, L.x.1, CWDM, Multirate, etc. and for Ethernet ports attribute values are 100Base-LX10, 100Base-ZX, 100Base-FX, etc.

Interface module alarm notifications are

- If an interface module is not provisioned an "InterfaceModuleNotProvisoned" alarm notification is raised, depending on the port state.
- If an interface module is provisioned, but not present an "InterfaceModuleMissing" alarm notification is raised, depending on the port state.
- If an interface module is provisioned but the installed module is not according to the expected interface module a "InterfaceModuleMismatch" alarm notification is raised, depending on the port state.
- If an interface module is not approved, an "InterfaceModuleNotApproved" alarm notification is raised, depending on the port state.

Interface module provisioning is independent of MSP/SNCP protection configuration, cross-connections, synchronisation settings, port structuring, DCC configuration, AUX configuration, etc.

The traffic interfaces that are based on the SFP multi source agreement (MSA) are possible to add in the field. The modules support hot insertion.

AXXESSIT provides a list of approved manufacturers and types. A manufacturer may be approved for some interface types, but not necessarily for all.

The approval-list is implemented as a separate file. If new manufacturers or types are added or removed from the list, a new Network Release (Maintenance Release) is issued. If nothing else is changed, only this file is downloaded.

A module that is of a correct type, but not qualified by AXXESSIT can be used. This generates an alarm and AXXESSIT cannot guarantee that the AXXMETRO meets all specifications.

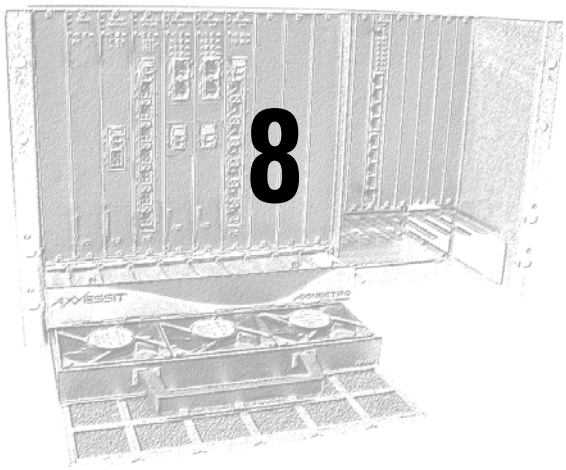
A module that is not qualified by AXXESSIT and is not of the correct type is disabled and an alarm is generated.

The following SPFs are currently available for use with AXXMETRO:

SFP	Description
SFP S.1.1	Small Form-factor Pluggable Optical module S.1.1
SFP L.1.1	Small Form-factor Pluggable Optical module L.1.1
SFP L1.2	Small Form-factor Pluggable Optical module L1.2
SFP STM-1e	Small Form-factor Pluggable Electrical module STM-1e
SFP S.4.1	Small Form-factor Pluggable Optical module S.4.1
SFP L.4.1	Small Form-factor Pluggable Optical module L.4.1
SFP L.4.2	Small Form-factor Pluggable Optical module L.4.2
SFP S.16.1	Small Form-factor Pluggable Optical module S.16.1
SFP L.16.1	Small Form-factor Pluggable Optical module L.16.1
SFP L.16.2	Small Form-factor Pluggable Optical module L.16.2
SFP 1000Base-TX	Small Form-factor Pluggable Electrical module
SFP 1000Base-LX10	Small Form-factor Pluggable Ethernet Optical module (SM, 1310 nm)
SFP 1000Base-SX	Small Form-factor Pluggable Ethernet Optical module (MM, 850 nm)
SFP 1000Base-ZX	Small Form-factor Pluggable Ethernet Optical module (SM, 1550 nm, 80 km)
SFP 100Base-FX	Small Form-factor Pluggable Ethernet Optical module (MM, 850 nm)
SFP 100Base-LX10	Small Form-factor Pluggable Ethernet Optical module (SM, 1310 nm)
SFP 100Base-ZX	Small Form-factor Pluggable Ethernet Optical module (SM, 1550 nm, 80 km)

Table 7.71. AXXMETRO SPFs

MECHANICS & CHARACTERISTICS



8.1 MECHANICAL FEATURES

8.1.1 Mechanical concept

The AXXMETRO is provided as a shelf suitable for mounting within a 19-inch or ETSI equipment cabinet. The shelf comprises a sub-rack with room for 21 modules, cable management area and fan tray.

The height of the unit is 6 RU (265 mm).

The part supporting the modules has room for two aggregate modules, eight tributary modules, two miscellaneous modules, eight connector modules and a fan module.

It is possible to mount one single unit including power supply, cable terminating and cable handling facilities, within an enclosure with external dimensions less than:

Width	449 mm
Height	266.7 mm
Depth	280 mm

The size of the shelf has the following physical dimension:

Width	447 mm
Height	265.9 mm
Depth	274.5 mm

The maximum front mounting depth aperture is 38mm.

The shelf is equipped with 19" brackets as a default as specified in IEC 60917 and IEC 60297.

Mounting brackets for ETSI cabinets/racks as specified in ETS 300 119 are available.

The mechanical design of the AXXMETRO meets the requirements of EN/IEC 60950.

The AXXMETRO has an optional removable front shelf cover. The system cover is not required for EMC purposes. EMC compliance is obtained in the AXXMETRO with all slots filled with modules, and/or blanking panels.

The total weight of the AXXMETRO fully equipped does not exceed 25 kg and the weight of an empty shelf does not exceed 10 kg.

8.1.2 Fiber cable management area

All modules in AXXMETRO support front cabling. All fiber cables and gigabit Ethernet copper cables are terminated on the front of the aggregate and tributary modules. The copper cables for STM-1e are terminated on the front of the aggregate or tributary module if SFP modules are

used. All other cables are terminated in the miscellaneous and connector modules. Note that the fast Ethernet copper cables are terminated in the relevant connector cards.

NOTE! **The Fast Ethernet copper cables are terminated in the relevant connector cards.**

The cable management area supports cables from the aggregate and tributary modules. A maximum of 136 fibers is supported with a maximum of 16 fibers from the tributary modules and 4 from the aggregate modules.

It is also able to handle copper cable from the gigabit Ethernet tributary modules and STM-1e SFP modules. The maximum number of Ethernet cables is 16 with up to two from every tributary module. The copper cable can be either UTP-5 or STP-5 types. The maximum number of STM-1e copper cables is 128 when using RG-179 cables.

The cable management area provides adequate cable dressing to ensure access to single plug-in modules without removing or adjusting cables connected to other in-service plug-in modules or to the front of the shelf.

Optical fibers connected to and within the system meet the bend radius requirements of ETSI (30 mm).

Note that the cables from the cable management area exit the shelf at both the left hand side and the right hand side of the shelf. The cabling from slot 1 to 5 exits to the left and the cabling from slot 6 to 10 exits to the right.

8.1.3 Copper cable management area

The copper cables from the miscellaneous and connector modules are handled differently from the fibers and gigabit Ethernet copper cables. Dedicated access slots in the right hand side of the shelf routes the cables out of the shelf.

This cable area handles up to 64 Ethernet cables (UTP-5/STP-5), 8 multi interface cables for E1, 128 coaxial cables (RG-179) or a mix of the different cables. It also handles the miscellaneous cabling (e.g. power, synchronisation, auxiliary, management and alarm cables) from both miscellaneous modules.

The cable management area provides adequate cable dressing to ensure access to single plug-in modules without removing or adjusting cables connected to other in-service plug-in modules or to the front of the shelf.

All cables from the copper cable management area leave the shelf at the right side. The cables do not interfere with the fibers from the fiber cable management area.

8.1.4 Fan tray and airflow management

The thermal design of the AXXMETRO meets the requirements of EN/IEC 60950.

The shelf uses forced air-cooling to control the internal temperature of the equipment. There is room for a fan module and a fan filter in the bottom of the shelf. The fan tray draws air from the lower portion of the shelf and moves air upwards through the system.

Access to the fiber management area is not required to administer fan and filter maintenance. Replacement and removal of fan module and filter does not impact traffic.

Airflow is managed within the shelf such that the system operates within environmental compliance parameters.

When multiple shelves are installed within a rack, airflow management is maintained such that system operation is guaranteed at the outside air ambient temperature range specified in the environmental compliance section of this document.

If the system is located in a rack and there is any heat-generating equipment below it, an air-ramp is required between the AXXMETRO shelf and the lower system.

8.1.5 Aggregate modules (AM)

The aggregate modules in the AXXMETRO have the following physical dimensions:

Depth:	199.5 mm
Height:	182.6 mm
Width:	24.5 mm

8.1.6 Tributary modules (TM)

The tributary modules in the AXXMETRO have the following physical dimensions:

Depth:	199.5 mm
Height:	182.6 mm
Width:	24.5 mm

8.1.7 Miscellaneous modules (MM)

The miscellaneous modules in the AXXMETRO have the following physical dimension:

Depth:	99.5 mm
Height:	182.6 mm
Width:	18.5 mm

8.1.8 Connector modules (CM)

The connector modules come in single width and double width variants.

The single width connector modules in the AXXMETRO have the following physical dimension:

Depth:	99.5 mm
Height:	182.6 mm
Width:	18.5 mm

The double width connector modules in the AXXMETRO have the following physical dimension:

Depth:	99.5 mm
Height:	182.6 mm
Width:	37.5 mm

8.1.9 FAN module

The FAN module in the AXXMETRO has the following physical dimensions:

Depth:	203.9 mm
Height:	25.9 mm
Width:	247.8 mm

8.2 CABLING

8.2.1 Power cables

Power cables are provided for AXXMETRO. The cables are optimised for use in racks.

Only one power source can be connected with one power cable. Two power cables are needed if a redundant power feeding is going to be used.

The power cable connects the AXXMETRO to the internal -48V power-rails in the rack. It has a 3-pin power DSUB-fit connector in one end and is not terminated in the other end. The customer must add the preferred type of connector to the end that is not terminated.

The cable is not screened.

The length of the power cables is 3m.

8.2.2 Alarm cables

Alarm cables are not provided, but it is easy for the customer to make his own cable. The physical connector is a 15 pin DSUB.

The alarm cable would typical be used to connect the AXXMETRO to the rack-top alarm indicators or to external alarm input sources.

The cable can be unshielded.

8.2.3 VT-100 cable

A cable that connects the AXXMETRO to a PC is available. This cable has a RJ-45 connector in one end and a 9 pins DSUB connector in the other end.

The cable is not shielded.

The length of the power cables is 3m.

8.2.4 LAN cables

Not provided

Ordinary UTP-5 or STP-5 cables can be used. Note that STP-5 cabling must be used for GE traffic

8.2.5 E1 cables

The E1 interface use standard shielded ISDN cabling. A balun is provided if a 75-ohm interface is needed.

8.2.6 High density E1 cables

Special cables for the high-density modules are provided for connection between the AXXMETRO and a patch-panel. The cable is terminated with a Molex LFH connector in both ends.

The cables are available with lengths of 3m, 10m and 25m. Other lengths are available on request.

8.2.7 Fiber cables

The optical interfaces for the AXXMETRO are based on the LC connector.

We recommend to use LC connectors (UPC polishing type) with a back reflection of at least 50 dB.

TIP **In many cases ordinary LC connectors (PC polishing type) can be used.**

Patch cords are not provided by AXXESSIT, but are available from many suppliers.

NOTE! **The angled boot is needed to be able to meet the minimum-bending radius of 30mm.**

The maximum cable diameter is 2 mm.The size of the cable guiding area sets the limit for the maximum cable diameter to 2 mm. It is possible to use 3 mm cables if fewer cables are used.

The cable guiding also supports a physical load of 60N.

8.3 ENVIRONMENT

8.3.1 Storage, transport and operation

The equipment meets the following requirements for operational, transportation and storage environment as specified in ETS 300 019 (See table below).

Requirement	Specification	Classes
Storage	ETS 300 019-2-1	
Transportation	ETS 300 019-2-2	Class 2.1, 2.2 and 2.3
Operational (mandatory)	ETS 300 019-2-3	Class 3.1, 3.1E and 3.2
Operational (optional)	ETS 300 019-2-3	Class 3.4

Table 8.1. Environmental classifications

Extracts from the specification

NOTE! **For special conditions, please refer to the ETSI specifications listed in Table 8.1.**

Requirement	Specification	Class	Air Temperature		Relative Air Humidity	
			Min	Max	Min	Max
Storage	ETS 300 019-2-1	1.1	-5°C	+45°C	5%	95%
Operational (mandatory)	ETS 300 019-2-3	3.1	+5°C	+40°C	5%	85%
Operational (optional)	ETS 300 019-2-3	3.4	-40°C	+70°C	10%	100%

Table 8.2. Extracts from ETSI environment requirements

8.3.2 Electromagnetic compatibility

The AXXMETRO meets the requirement for EMC as specified in EN 300 386 for use in Telecom Centres.

The power supply interfaces meet the requirements as specified in ETS 300 132-2.

8.3.3 Health and safety

The equipment meets the safety requirements specified in EN/IEC 60950.

It also meets the optical safety requirement specified in EN 60825.

The equipment meets the requirements in ETS 300 753 for acoustic noise.

8.3.4 Grounding and bonding

The equipment meets the grounding and bonding requirements of ETS 300 253.

The shelf is made of metal and it is connected to signal ground inside. The shelf has a dedicated ground connector for connection to external ground.

The screens of all external cables are connected to signal ground/shelf ground.

A dedicated ground connector is available in the shelf. It is implemented with a screw that is connected to the chassis. The ground cable is connected to the chassis with this screw.

8.3.5 Environmental conditions

The equipment conforms to the requirement of EN 300 386 for EMC related specifications. The equipment is also compliant with the following standards:

EN 50082-1

EN 50081-1

EN 55022

EN 55024

EN 61000-3-2

EN 61000-3-3

EN 61000-4-2

EN 61000-4-3

EN 61000-4-4

EN 61000-4-5

EN 61000-4-6

EN 61000-4-11

EN60950, The Low Voltage Directive.

The equipment operates under all environmental conditions detailed in ETS 300 019-2-3 Class 3.2.

8.3.6 Health and safety

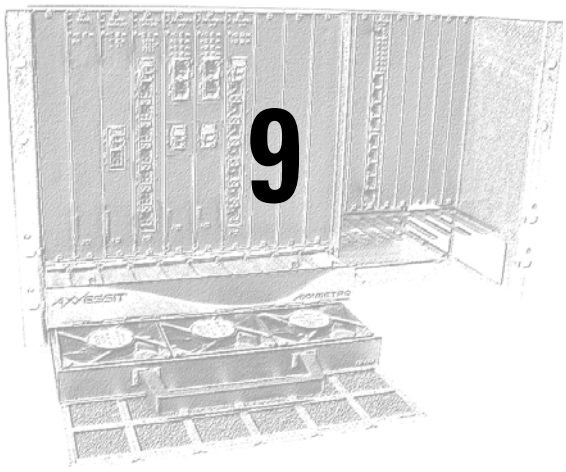
The equipment meets the requirements in EN/IEC 60950 and EN60825.

The equipment meets the requirements in ETS 300 753 for acoustic noise.

8.3.7 Storage and transport

The equipment meets the requirements in ETS 300 019, Class 1.1 and class 2.2.

Supported storage temperature range: -40^{O}C to +70^{O}C.



REFERENCE

9.1 INTRODUCTION

This chapter contains reference information divided into the following sections:

- "Definitions"
- "Abbreviations"
- "ITU-T Recommendations"
- "Cenelec Documents"
- "ETSI documents"
- "IEC documents"
- "IEEE recommendations"
- "IETF recommendations"
- "ISO recommendations"
- "Metro Ethernet Forum"
- "Bellcore documents"
- "Miscellaneous recommendations:"

9.2 DEFINITIONS

Item	Description
Shelf	The shelf consists of the mechanical sub-rack with an internal back plane.
Module	A module consists of one or multiple cards, sub-modules, interface modules and mechanical parts (e.g. front panel, ejectors, shielding plate, etc.) that can be plugged into a shelf as a single physical unit.
Sub-module	A small module consisting of one or multiple cards, interface modules and mechanical parts that can be plugged into a module.
Interface module	A physical interface module that can be plugged into a module or a sub-module (e.g. modules based on the SFP multi-source agreement)
Card	A single printed circuit board with components.
Hitless	Used in protection switching and denotes less than 50ms traffic disruption.
Errorless	Used in protection switching and denotes no bit errors.
Upstream	The direction towards the matrix.
Downstream	The direction from the matrix.

Item	Description
Uplink	The uplink concept is used in ISDN PRA and it is defined as the direction from the TE towards the ET.
Downlink	The downlink concept is used in ISDN PRA and it is defined as the direction from the ET towards the TE.
Line loopback	The incoming (upstream) signal is looped back towards the line.
Terminal loopback	The outgoing (downstream) signal is looped back towards the matrix.
EOS mapper	A functionality that maps Ethernet traffic into SDH virtual containers.
LANx port	This is a standard physical Ethernet port according to IEEE specifications. The LANx port is internally connected to a port on the internal Ethernet switch for L2 functions or to an EOS mapper for L1 functions
WANx port	This is a port on the internal Ethernet switch that is always connected to an EOS mapper.

9.3 ABBREVIATIONS

Abbreviation	Meaning
2F	Two fiber
4F	Four fiber
AC	Alternating Current
ADM	Add and Drop Multiplexer
AIS	Alarm Indicating Signal
ALS	Automatic Laser Shutdown
AM	Aggregate Module
ANSI	American National Standards Institute
ARP	Address Resolution Protocol
AUG	Administrative Unit Group
B3ZS	Bipolar 3 Zero Substitution
BALUN	BALanced to UNbalanced
BBE	Background Block Error
BBER	Background Block Error ratio
BPDU	Bridge Protocol Data Unit
BW	Bandwidth
CDP	Cisco Discovery Protocol
CE	Customer Edge
CF	Coupling Flag
CIR	Committed Information Rate
CBR	Committed Burst Rate
CLI	Command Line Interface

Abbreviation	Meaning
CLNP	ConnectionLess Network Protocol
CM	Connector Module
CM	Coupling Mode
CMI	Coded Mark Inversion
COS	Class Of Service
CORBA	Common Object Request Broker Architecture
CPE	Customer Premises Equipment
CPLD	Complex Programmable Logic Device
CPR	Coupled Power Ratio
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CT	Craft Terminal
CU	Consolidation Unit
CWDM	Coarse Wavelength Division Multiplexing
DC	Direct Current
DCC	Data Communication Channel
DCCX	Data Communication Channel Cross-connect
DCD	Duty Cycle Distortion
DCN	Data Communication Network
DE	Drop Eligible
DECNET	Digital Equipment Corporation Networking architecture
DMUX	De-Multiplexer
DNU	Do Not Use
DSCP	DiffServe Code Points
DSUB	Subminiature D connector
DWDM	Dense Wavelength Division Multiplexing
EBR	Excessive Burst Rate
EEPROM	Electrical Erasable Programable Read Only Memory
EIR	Excessive Information Rate
E-LAN	Ethernet LAN service
E-LINE	Ethernet LINE service
EM	Element manager
EMC	ElectroMagnetic Compatibility
EMEA	Europe, Middle East and Africa
EOS	Ethernet Over SDH
EPL	Ethernet Private Line
EPLAN	Ethernet Private LAN
ES	End System
ES	Errored Second
ESR	Errored Second Ratio

Abbreviation	Meaning
ET	Exchange Terminal
ETSI	European Telecommunications Standards Institute
EVC	Ethernet Virtual Connection
EVPL	Ethernet Virtual Private Line
EVPLAN	Ethernet Virtual Private LAN
EXP	EXPerimental bits
FC/PC	fiber Connector/Polished Contact
FCS	Frame Check Sequence
FD	Frame Delay
FDV	Frame Delay Variation
FE	Fast Ethernet
FIFO	First In First Out
FLR	Frame Loss Ratio
FPGA	Field Programmable Gate Array
GARP	Generic Attribute Registration Protocol
GE	Gigabit Ethernet
GFP	Generic Framing Procedure
GMRP	GARP multicast Registration Protocol
GSM	Global System for Mobile communication
GTL	Gunning Transistor Logic
GUI	Graphical User Interface
GVRP	GARP VLAN Registration Protocol
GW	GateWay
HDB3	High Density Bipolar order 3
HDLC	High-level Data Link Control
HEC	Header Error Check
HO	Hold Off time
HOLB	Head Of Line Blocking
IAD	Integrated Access Device
I2C(IIC)	Inter-IC bus
ID	IDentifier
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IPPM**	Intermediate Path Performance Monitoring
IPX	Internetwork Packet eXchange
IS	In Service
IS	Intermediate System

Abbreviation	Meaning
ISDN	Integrated Services Digital Network
ISO	International organisation for standardisation
ITU	International Telecommunication Union
L1	Layer 1
L1CC	Layer 1 Communication Channel
L2	Layer 2
L3	Layer 3
LACPDU	LACP Data Units
LAG	Link Aggregation Group
LAN	Local Area Network
LAPS	Link Access Procedure SDH
LCAS	Link Capacity Adjustment Scheme
LED	Light Emitting Diode
LFA	Loss of Frame Alignment
LFH	Low Force Helix
LLC	Logical Link Control
LOF	Loss Of Frame alignment
LOS	Loss Of Signal
MAC	Media Access Control
MCN	Management Communication Network
MDI	Medium Dependent Interface
MEF	Metro Ethernet Forum
MEN	Metro Ethernet Network
MM	Miscellaneous Module
MMF	Multi Mode fiber
MPLS	Multi Protocol Label Switching
MSA	Multi Source Agreement
MSOH	Multiplex Section OverHead
MSP	Multiplex Section Protection
MSPP	Multi Service Provision Platform
MS-AIS	Multiplex section - Alarm Indication Signal
MS-SPRING	Multiplex Section Shared Protection Rings
MSTP	Multiple Spanning Tree Protocol
MTBF	Mean Time Between Failures
MUX	Multiplexer
NE	Network Element
NetBIOS	Network Basic Input/Output System
NM	Network manager
NNI	Network Network Interface
NSAP	Network Service Access Point

Abbreviation	Meaning
OAM	Operation Administration Maintenance
OAMPDU	OAM Protocol Data Unit
OOS	Out Of Service
OOS-AINS	Out Of Service - Auto IN Service
OOS-MT	Out Of Service - MainTenance
OSI	Open System Interconnect
OSPF	Open Shortest Path First
PABX	Public Access Business eXchange
PC	Personal Computer
PCI	Peripheral Component Interchange
PCP	Priority Code Point
PCS	Physical Coding Sub-layer
PFI	Payload FCS Identifier
PHY	PHYsical layer device
PJE	Pointer Justification Event
PJEL	Pointer Justification Event Limit
PM	Performance Monitoring
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent
POP	Point Of Presence
PPP	Point to Point Protocol
PRA	Primary Rate Access
PRC	Primary Reference Clock
PSC	Protection Switch Count
PSD	Protection Switch Duration
QL	Quality Level
QLM	Quality Level Minimum Threshold
RDI	Remote Defect Indicator
RFC	Request For Comments
RMII	Reduced Media Independent Interface
RMON	Remote MONitoring
RMS	Root Mean Square
RS-TIM	Regenerator Section - Trace Identifier Mismatch
RSOH	Regenerator Section OverHead
RSTP	Rapid Spanning Tree Protocol
RTC	Real Time Clock
RU	Rack Units
SA	Spare bits
SC	Subscription Channel Connector
SDH	Synchronous Digital Hierarchy

Abbreviation	Meaning
SDRAM	Synchronous Dynamic Random Access Memory
SEC	SDH Equipment Clock
SERDES	Serialiser deserialiser
SES	Severely Errored Second
SESR	Severely Errored Second Ratio
SETS	Station Equipment Timing Synchronisation
SFP	Small Form Pluggable
SMF	Single Mode fiber
SLA	Service Level Agreement
SNA	System Network Architecture
SNAP	Sub Network Access Protocol
SNC/I	Sub Network Connection/Inherent
SNC/N	Sub Network Connection/Non Inherent
SNCP	Sub Network Connection Protection
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical NETwork
SSM	Synchronisation Status Messages
SSU	Synchronisation Supply Unit
STM	Synchronous Transport Module
STP	Spanning Tree Protocol
TCI	Tag Control Identifier
TDM	Time Division Multiplexing
TE	Terminal Equipment
TM	Tributary Modules
TMF	TeleManagement Forum
TMN	Telecommunication Management Network
TOS	Type Of Service
TPID	Tag Protocol Identifier
UART	Universal Asynchronous Receiver Transmitter
UAS	Unavailable Seconds
UNI	User Network Interface
USB	Universal Serial Bus
UTP	Un-screened Twisted Pair
VC	Virtual Container
VCG	Virtual Container Group
VID	VLAN IDentifier
VLAN	Virtual Local Area Network
VTP	VLAN Trunk Protocol
WAN	Wide Area Network

Abbreviation	Meaning
WTR	Wait To Restore
XFP	10 gigabit small Form-factor Pluggable

9.4 ITU-T RECOMMENDATIONS

Standard	Description
G.652	Single Mode Optical fiber
G.664	Optical safety procedures and requirements for optical transport systems
G.694.2	Spectral grids for WDM applications: CWDM wavelength grid
G.701	Vocabulary of Transmission and Multiplexing, and Pulse Code Modulation (PCM) Terms.
G.702	Digital Hierarchy Bit Rates
G.703	Physical/Electrical Characteristics of Hierarchical Digital Interfaces
G.704	Synchronous Frame Structures at Primary and Secondary Hierarchical levels
G.706	Frame Alignment and Cyclic Redundancy Check (CRC) Procedures Relating to Basic Frame Structures Defined in Recommendation G.704
G.707	Network node interface for the synchronous digital hierarchy (SDH)
G.732	Characteristics of Primary PCM Multiplex Equipment operating at 2048 kbit/s
G.775	Loss of Signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals
G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
G.784	Synchronous digital hierarchy (SDH) management
G.806	Characteristics of transport equipment - Description methodology and generic functionality
G.810	Definition and terminology for synchronisation networks
G.811	Timing characteristic of primary reference clocks
G.812	Timing characteristics of slave clocks suitable for use as a node clocks in synchronisation networks
G.813	Timing characteristics of SDH equipment slave clocks (SEC)
G.823	The control of jitter and wander within digital networks which are based on the 2048 kbps hierarchy
G.824	The control of jitter and wander within digital networks which are based on the 1544 kbps hierarchy
G.825	The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)
G.826	Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate
G.828	Error performance parameters and objectives for international, constant bit rate synchronous digital paths

Standard	Description
G.832	Transport of SDH elements on PDH networks - Frame and multiplexing structures
G.841	Types and characteristics of SDH network protection architectures
G.957	Optical interfaces for equipment and systems relating to the synchronous digital hierarchy
G.958	Digital line systems based on the synchronous digital hierarchy for use on optical fiber cables
G.7041	Characteristics of transport equipment - Description methodology and generic functionality
G.7042	Link Capacity Adjustment Scheme (LCAS) for virtual concatenated signals.
K.41	Resistibility of internal interfaces of telecommunication centres to surge overvoltages
V.28	Electrical characteristics for unbalanced double-current interchange circuits

9.5 CENELEC DOCUMENTS

EN 50082-1

Generic immunity standard Industrial environment

EN 55022

Specification for Limits and methods of Measurement of Radio Interference Characteristics of Information Technology Equipment

EN 55024

Electromagnetic Compatibility Requirements for Information Technology Equipment (Previously EN 55101)

9.6 ETSI DOCUMENTS

ETS 300 011

Integrated Services Digital Network (ISDN); Primary rate user-network interface; Layer 1 specification and test principles

ETS 300 019-2-1

Environmental engineering (EE); Environmental conditions and environmental tests for telecommunication equipment Part 2-1: Specification of environmental test; Storage

ETS 300 019-2-2

Environmental engineering (EE); Environmental conditions and environmental tests for telecommunication equipment Part 2-2: Specification of environmental test; Transportation

ETS 300 019-2-3

Environmental engineering (EE); Environmental conditions and environmental tests for telecommunication equipment Part 2-2: Specification of environmental test; Stationary use at weather protected locations

ETS 300 119-3

Equipment Engineering (EE); European telecommunication standard for equipment practice Part 3: Engineering requirements for miscellaneous racks and cabinets

ETS 300 119-4

Equipment engineering (EE): European telecommunication standard for equipment practice Part 4: Engineering requirements for subracks in miscellaneous racks and cabinets

ETS 300 132-2

Environmental engineering (EE): Power supply interface at the input to the telecommunication equipment: Part 2 Operated by direct current (dc)

ETS 300 147

Transmission and multiplexing (TM); Synchronous digital hierarchy (SDH); Mulitiplexing structure

ETS 300 233

Integrated Services Digital Network (ISDN); Access digital section for ISDN primary rate

ETS 300 246

Business Telecommunications (BT); Open Network Provision (ONP) technical requirements; 2 048 kbps digital unstructured leased line (D2048U) Network interface presentation.

ETS 300247

Access and Terminals (AT); 2 048 kbps digital unstructured leased line (D2048U); Connection characteristics

ETS 300 253

Environmental engineering (EE): Earthing and bonding configuration inside telecommunication centres

ETS 300 386

Electromagnetic compatibility and radio spectrum matters (ERM); Telecommunication network equipment; Electromagnetic compatibility (EMC) requirements

ETS 300418

Access and Terminals (AT); 2 048 kbps digital unstructured and structured leased lines (D2048U and D2048S); Network interface presentation

ETS 300419

Access and Terminals (AT); 2 048 kbps digital structured leased lines (D2048S); Connection characteristics

EN 300462-3-1

Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 3-1: The control of jitter and wander within synchronization networks

EN 300462-5-1

Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 5-1: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment

EN 300462-7-1

Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 7-1: Timing characteristics of slave clocks suitable for synchronization supply to equipment in local node applications

ETS 300753

Equipment engineering (EE): Acoustic noise emitted by telecommunication equipment

9.7 IEC DOCUMENTS

IEC 60297-2

Dimensions of mechanical structures of the 482.6 mm (19 inch) series - Part 2: Cabinets and pitches of rack structures

IEC 60297-3

Dimensions of mechanical structures of the 482.6 mm (19 inch) series - Part 3: Subracks and associated plug-in units

IEC 60825-1

Safety of laser products - Part 1: Equipment classification, requirements and user's guide

IEC 60825-2

Safety of laser products - Part 2: Safety of optical fibre communication systems

IEC 60950-1

Information technology equipment - Safety - Part 1: General requirements

9.8 IEEE RECOMMENDATIONS

IEEE 802.1D

IEEE Standard for Information technology--Telecommunications and information exchange between systems--IEEE standard for local and metropolitan area networks--Common specifications--Media access control (MAC) Bridges

IEEE 802.1p

Included in IEEE 802.1D

IEEE 802.1Q

IEEE Standard for Local and Metropolitan Area Networks: Virtual bridged local area networks

IEEE 802.1w

Part 3: Media Access Control (MAC) Bridges - Amendment 2: Rapid Reconfiguration

IEEE 802.1X

Port-Based Network Access Control

IEEE 802.2

IEEE Standard for Information technology--Telecommunications and information exchange between systems--Local and metropolitan area networks--Specific requirements--Part 2: Logical Link Control

IEEE 802.3

Information technology--Telecommunications and information exchange between systems--Local and metropolitan area networks--Specific requirements--Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

IEEE 802.3ah

IEEE Standard for Information technology. Telecommunications and information exchange between systems. Local and metropolitan area networks. Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks

IEEE 802.3ad

Included in 802.3 (2002)

9.9 IETF RECOMMENDATIONS

RFC 768

User Datagram Protocol (UDP)

RFC 791

Internetwork Protocol

RFC 793

Transmission Control Protocol (TCP)

RFC 826

An Ethernet Address Resolution Protocol

RFC 894A

Standard for the Transmission of IP Datagrams over Ethernet Networks

RFC 1127A

Perspective on the Host Requirements RFCs

RFC 1332

The PPP Internet Protocol Control Protocol

RFC 1661

Point to Point Protocol

RFC 1662

PPP in HDLC-like framing

RFC 1213

Management Information Base for Network Management of TCP/IP based internets: MIB-II

RFC 2037

Entity MIB using SMIv2

RFC 1493

Definition of Managed Objects for Bridges.

RFC 1238

CLNS MIB for use with Connectionless Network Protocol (ISO 8473) and End System to Intermediate System (ISO 9542)

RFC1812

Requirements for IP Version 4 Routers

RFC 2328

OSPF Version 2

RFC 2495

Definitions of Managed Objects for the DS1, E1, DS2 and E2 interface types.

RFC 2558

Definitions of Managed Objects for the SONET/SDH interface type.

RFC 2698A

Two Rate Three Color Marker

RFC 2665

Definitions of Managed Objects for the Ethernet-like Interface Types

RFC 2784

Generic Routing Encapsulation

RFC 2819

Remote Network Monitoring Management Information Base

RFC 3147

Generic Routing Encapsulation over CLNS Networks

9.10 ISO RECOMMENDATIONS

ISO 4335

High-level Data Link Control (HDLC) procedures

ISO 8473

Protocol for Providing the Connectionless-mode Networking Service (CLNS)

ISO 9542

End System to Intermediate System Protocol (ES-IS) for Use in Conjunction with ISO 8473

ISO 10589

Intermediate System to Intermediate System Protocol (IS to IS)

9.11 METRO ETHERNET FORUM

MEF 4

Metro Ethernet Network Architecture Framework - Part 1: Generic Framework

MEF 6

Ethernet Services Definitions Phase 1

MEF 10

Ethernet Service Attributes Phase 1

MEF 11

User Network Interface (UNI) Requirements and Framework

9.12 BELLCORE DOCUMENTS

GR-253

Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria

SR-332

Reliability prediction procedure for electronic equipment

9.13 MISCELLANEOUS RECOMMENDATIONS:

NSIF-DN-0101-001

A Standard for IP over DCC

DIX-2

Digital Equipment Corporation, Intel, Xerox, The Ethernet, Version 2.0, November 1982

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- Open solutions in a multi-vendor environment
- Highly flexible and scalable solutions enable seamless migration towards NGAN
- All Telecom- and networking services over one single link regardless of infrastructure
- Willingness to understand customer needs and ability to meet them
- Support of Remote Network Management makes Ericsson AXXESSIT equipment simple to install, maintain and upgrade

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