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Bell Labs Innovations

WaveStar® ADM 16/1

Application and Planning Guide

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About this document

A

Purpose

This Application and Planning Guide provides information about the features, applications, operation, engineering, support and specifications of the WaveStar® ADM 16/1 Multiplexer and Transport system. This Application and Planning Guide is the most recent version of the Pearl release, R5.1.

The WaveStar® ADM 16/1 is a high-capacity intelligent multiplexer and transport system able to multiplex standard PDH, Ethernet and SDH bit rates to a higher level up to 2.5 Gbit/s (STM-16). Because of this wide range in capacity, this system is a useful element in building efficient and flexible networks.

The WaveStar® ADM 16/1 system consists of one common hardware platform. This platform can serve a family of equipment and software configurations designed to support a particular set of applications.

The WaveStar® ADM 16/1 supports a large variety of configurations for various network applications:

- STM-16, STM-4, STM-1 point-to-point (end) terminal connections. Options are: 0x1 terminal with no line protection and 1+1 MSP line-protected terminal
- STM-16, STM-4, STM-1 two fiber add/drop terminal in linear applications and rings
- Hubbing functionality
- Small cross-connect
- Broadcasting functionality
- Payload concatenation:
  - Virtual Concatenation on WaveStar® TransLAN™ Card
  - Interconnecting ATM systems via VC-4-4c concatenation
- Tributary interface mixing
- Single ADM for interconnection of STM-16, STM-4 and STM-1 rings (ring closure)
- Dual node interworking (DNI) with drop & continue

- SONET-SDH Conversion and Interworking
- Multi-Service applications with WaveStar® TransLAN™ Card.

In this Application and Planning Guide of the WaveStar® ADM 16/1, all features are presented up to and including the Pearl release, R5.1.

Intended audience

This Application and Planning Guide is primarily for network planners and engineers. However, it is also useful for anyone who needs specific information about the features, applications, operation and engineering of the WaveStar® ADM 16/1 Multiplexer and Transport System.

How to use this document

This Guide is organized as follows

- About this document

  Describes the purpose, intended audience, and organization of this document. This section also references other related documentation.

- Chapter 1, Introduction

  This Chapter describes the WaveStar® ADM 16/1.

- Chapter 2, Features and Benefits

  This chapter briefly describes the Features and Benefits of the WaveStar® ADM 16/1. These are described in greater detail in Chapter 3 “Applications”, Chapter 4 “Product Description”, Chapter 5 “Operation, Administration, and Provisioning”, Chapter 6 “Physical design” as applicable.

- Chapter 3, Applications

  This chapter describes how the WaveStar® ADM 16/1 platform meets various needs relating to network-level-specific topologies. In addition, it describes needs and provided functionality relating to various different applications such as point-to-point, ring, hubbing, etc.

  Also special system versions for applications in combination with other products of the Lucent Technologies family of SDH products are briefly discussed.

- Chapter 4, Description

  This chapter describes the WaveStar® ADM 16/1 architecture. After an introduction of the WaveStar® ADM 16/1 platform, the system control, transmission, synchronization, protection and powering are described down to circuit pack level.

- Chapter 5, Operation, Administration, Maintenance, and Provisioning

  This chapter defines the “maintenance philosophy” outlining the various features available to monitor and maintain the WaveStar® ADM 16/1.

- Chapter 6, Cross-Product Interworking

  This chapter briefly describes the interworking between the WaveStar® ADM 16/1 and other products of Lucent Technologies’ SDH product family.

- Chapter 7, Physical Design

  This chapter describes the physical design, subrack, rack layouts and the connector panels of the WaveStar® ADM 16/1.

- Chapter 8, System Planning and Engineering

This chapter summarizes descriptive information used with the application information to plan procurement deployment of the WaveStar® ADM 16/1.

- Chapter 9, Technical Data

  This chapter lists the detailed technical specifications for the WaveStar® ADM 16/1.

- Chapter 10, Quality and Reliability

  This chapter describes Lucent Technologies' quality policy and describes the reliability of the WaveStar® ADM 16/1 in different configurations.

- Chapter 11, Product Support

  This chapter describes how Lucent Technologies supports the WaveStar® ADM 16/1. This includes information about engineering and installation services, technical support, documentation support, and training.

- Chapter 12, Glossary

  This chapter lists in alphabetic order all the terms and acronyms used in the Application and Planning Guide.

Differences between release 4.0 (Ruby) and 5.0 (Diamond)

1. New LAN unit (LJB459) with TransLAN features (FEP5536)
    1. Ethernet/Fast Ethernet mapping into VC-12-xv or VC-3-xv signals
    2. VPN services
    3. Interworking with WaveStar® ADM 16/1 Compact and WaveStar® AM 1 Plus WaveStar® TranLAN™ Card units
    4. Configurable Auto-negotiation function on WaveStar® TranLAN™ Card units
    5. Performance Monitoring on LAN connections
2. Provisioning of ss-bits (FEP5732)
    - In the source direction, the transmitted ss-bits can be provisioned in '10' (SDH mode,
    - default) or '00' (SONET mode). In the sink direction the incoming ss bits are ignored.
3. MS-SPRing event information available on WaveStar® ITM-SC NB CORBA Interface (FEP4920)

The WaveStar® ADM 16/1 provides the numerical value, called NID (between 0 and 15 - corresponding with the 4 bits in the K-byte protocol as per ITU-T G.841) to the WaveStar® ITM-SC. The WaveStar® ITM-SC will then make the event information available on the NB CORBA Interface.

4. Pointer Justification Event (PJE) counters on STM-N (FEP 5534)

The following parameters are available to estimate the synchronization performance:

- · PJE-: Count of negative pointer justifications
- · PJE+: Count of positive pointer justifications

Both counters are present on one outgoing AU-4 pointer generation circuit per outgoing STM-N.

5. AIS detection on 2Mbit/s ports for asynchronous mapping (FEP 5801)

It is possible to monitor the CRC-4, E-bit and A-bit information in TS0 of any 2 Mbit/s in both directions for performance monitoring purposes for G.704 structured 2 Mbit/s tributaries.

Differences between release 5.0 (Diamond) and 5.1 (Pearl)

1. 1200 monitoring points for full TCM emulation (FEP5718)

The WaveStar® ADM 16/1 supports the possibility to performance monitor 1200 monitor points simultaneously. Note: On WaveStar® ADM 16/1 this feature can only be used in combination with Ruby controller hardware (LJB457B) and Ruby Cross-connect-64/32 (LJB434).

2. TransLAN features (FEP 5517 and 5753)

With the Pearl Rainbow Release a number of new features are supported on the Ethernet LAN tributary board, LJB459. Please note that on WaveStar® ADM 16/1 these features are only supported with Ruby controller hardware (LJB457B).

1. Layer 2 VPN Data Policing

In addition to Multi-port LAN Bridging with VPN support the WaveStar® ADM 16/1 supports provisioning of data policing parameters at each external Ethernet port to allow L2 QoS and bandwidth management for each VPN of a L2 network.

Each external Ethernet port of a switching relation in VPN mode can get assigned data policing parameters. The following parameters are supported:

- Policing Mode with two possible values [Strict policing | Oversubscription] determined via provisioning a Peak Information Rate (PIR)

- Committed Information Rate (CIR) per Port/User-Priority or Port/VLAN/User-Priority (Diamond release, R5.0) relevant in both policing modes

In case of strict policing (PIR provisioned equal to CIR) all incoming packets from the associated external Ethernet port which exceed the provisioned CIR will be dropped. In over-subscription mode (PIR provisioned above CIR) packets exceeding the CIR will be marked by raising their drop precedence and only dropped if an congestion situation occurs during switching. This means that over-subscription mode allows a peak rate in the range of the physical line rate interconnecting the switches which are building the L2 network, but without any guaranteed bandwidth.

Note: It is the responsibility of the operator to ensure a suitable provisioning of CIR for each Ethernet port in relation to the under-laying L2 network topology to prohibit data congestion on any physical link which are interconnecting the switches of the network. With congestion the provisioned CIRs are not guaranteed.

2. Dual VLAN Tagging mode support

The WaveStar® ADM 16/1 is able to support both Port-based VPN Customer Tagging and IEEE 802.1Q VLAN Tagging. Lucent proprietary Port-based VPN Customer Tagging is already supported by the Diamond Release. Switching between tagging modes is traffic affecting and requires VLAN configuration re-engineering.

3. Traffic segregation via IEEE 802.1Q VLAN tag

The WaveStar® ADM 16/1 supports VLAN Tagging, Classification and Filtering compliant to IEEE802.1Q on all of its external Ethernet LAN ports or internal WAN ports. This Tagging mode is incompatible with the Port-based VPN Customer Tagging mode.

The packets are processed as follows:

- End-customer VLAN-tagged packets are VLAN classified according to the VLAN Id contained in the VLAN Tag. The system performs VLAN Ingress filtering based on port membership of the receive port to the specific VLAN.

- End-customer untagged and priority-tagged packets are VLAN classified according to a default Port VLAN Id (PVID identifying an end-customer with Port-based VPN Customer Tagging mode) assigned to the receive port. The system inserts the PVID in the VLAN Tag.

VLAN Id shall be unique among end-customers.

4. Ethernet/Fast Ethernet VLAN Trunking

The WaveStar® ADM 16/1 is able to aggregate Ethernet or Fast Ethernet traffic of multiple end-customers over a single external Ethernet port. Such a VLAN Trunk port is a shared member of multiple VLANs from different end-customers. The VLAN Id list is configurable as per IEEE 802.1Q VLAN Tagging.

5. Manual Provisioning of Spanning Tree parameters

From WaveStar® ITM-SC or ITM-CIT, the operator can manually provision the bridge parameters to force a specific spanning tree topology and ensure better bandwidth utilization.

The operator has access to a limited set of parameters regarding the active Spanning Tree topology and has means to control it for pro-active maintenance.

6. GVRP - automatic provisioning of VLAN ID in intermediate nodes

The WaveStar® ADM 16/1 supports the GARP VLAN Registration Protocol (GVRP) to help maintaining VLAN identification consistency and connectivity throughout the switched WAN network. GVRP is a Generic Attribute Registration Protocol (GARP)

application that provides VLAN pruning and dynamic VLAN creation on 802.1Q Trunk links. With GVRP, switches distribute automatically VLAN configuration information to other switches, prune unnecessary broadcast and unknown unicast traffic, and dynamically create and manage VLANs on switches connected to IEEE 802.1Q Trunk links. The GVRP protocol provides a mechanism for dynamic maintenance of the contents of the bridge filtering database. GVRP implementation is compliant with IEEE 802.1Q Clause 11.

Note: unlike Cisco's VLAN Trunk Protocol (VTP) protocol, standard GVRP does not propagate VLAN names.

Differences between release 5.1 (Pearl) and release 6.0 (Garnet)

FEP5905: 6 channel E3 and 6 channel DS3 unit for ADM 16/1.

The tributary unit PI-E3/6 has 6 interfaces of 34 Mbit/s and an impedance of 75 Ohms. The PI-DS3/6 has also 6 interfaces and an impedance 75 Ohms. However, the speed is 45 Mbit/s.

Differences between release 6.0 (Garnet) and release 6.1 (Garnet)

— IEEE 802.1w Rapid Spanning Tree

— Implement Ethernet GFP encapsualtion on the FE TransLAN card

— Capability to transport Ethernet-like frames of up to 1650 bytes length

— Fast download system software through Q-LAN interface

Differences between release 6.1 (Garnet) and release 6.2 (Garnet)

Gbe on ADM16/1

- Gigabit Ethernet 1000BASE-SX/LX interface
- Fast Ethernet to Gigabit Ethernet trunking
- Gigabit Ethernet “Lite”, point-to-point and rings
- Scalable bandwidth through virtual concatenation VC3/4-Xv and LCAS

Introduction

1

The WaveStar® ADM 16/1 Multiplexer and Transport System

The WaveStar® ADM 16/1 is a high-capacity Multiplexer and Transport system able to multiplex standard PDH and SDH bit rates to a higher level up to 2.5 Gbit/s (STM-16). Because of its wide range in capacity, this system is a useful element in building efficient and flexible networks.

The main strengths of the product are:

- Massive Multiservice Add/Drop capacity: up to 504x 1.5 Mbit/s, 504x 2 Mbit/s, 48x 34 Mbit/s, 96x STM-0, 96 x 45 Mbit/s, 64x1 0/100 Base-T Ethernet, 18x GbE interfaces (Gigabit Ethernet), 32x STM-1, 32x 140 Mbit/s or 8x STM-4 (possible to drop directly from the STM-16 level)
- Compact design
- Easy installation and maintenance
- Flexibility in applications and protection capabilities.

These features make the WaveStar® ADM 16/1 one of the most cost-effective, future-proof and flexible network elements available on the market today. Although the system has primarily been designed for STM-16 applications, it can also be used in STM-4 and STM-1 networks.

Various transmission protection mechanisms are supported by the WaveStar® ADM 16/1, such as:

- Multiplex Section Protection or MSP
- Path protection or SNCP/N (Sub Network Connection Protection with Non Intrusive Monitoring) for higher- and lower order VCs
- Multiplex Section Shared Protection Ring or MS SPRing at STM-16 level
- Dual Node Interconnection (DNI) with drop and continue

Like all network elements of Lucent Technologies SDH product portfolio, the WaveStar® ADM 16/1 is managed by Lucent Technologies Navis™ Optical Management Solution, a user-friendly network and element-level management system.

The WaveStar® ADM 16/1 is a third-generation SDH transport system. This system can be deployed together with other Lucent Technologies 1st and 2nd generation SDH products, today and in the future. This makes the WaveStar® ADM 16/1 one of the main building blocks of today's and future SDH networks.

Applications

The WaveStar® ADM 16/1 can be applied in all three Tiers of a network: Access, Regional and Backbone, although its main applications can be found at Regional and Backbone level. The system allows for growth and changing service needs by supporting in-service conversions and upgrades. Inherent to its basic design, the system operates equally well within fully synchronous as well as a-synchronous environments and provides a flexible link between the two.

The WaveStar® ADM 16/1 supports a large variety of configurations for various network applications:

- STM-16, STM-4, STM-1 point-to-point (end) terminal connections. Options are: 0x1 terminal with no line protection and 1+1 MSP line-protected terminal
- STM-16, STM-4, STM-1 two fiber add/drop terminal in linear applications and rings
- Hubbing functionality
- Small cross-connect
- Broadcasting functionality
- Payload concatenation:
  - Virtual Concatenation on WaveStar® TransLAN™ Card
  - Interconnecting ATM systems via VC-4-4c concatenation
- Tributary interface mixing
- Single ADM for interconnection of STM-16, STM-4 and STM-1 rings (ring closure)
- Dual node interworking (DNI) with drop & continue
- SONET-SDH Conversion and Interworking
- Multi-Service applications with WaveStar® TransLAN™ Card.

Main applications of the system:

- Grooming of lower order traffic in a ring
- Path protected rings
- Ring closure network element
- ADM in MS-SPRing protected STM-16 rings.

Concise System Description

A big step forward in technology resulted in this very flexible product. Because of the high level of integration at circuit-pack level, it is possible to Add/Drop up to 504x 1.5 Mbit/s, 504 x 2 Mbit/s, 48 x 34 Mbit/s, 96 x STM-0, 96 x 45 Mbit/s, 64x10/100 Base-T Ethernet, 18x GbE interfaces (Gigabit Ethernet), 32 x STM-1, 32 x 140 Mbit/s or 8 x STM-4 using only one subrack.

The WaveStar® ADM 16/1 is a multiplexer and transport system that multiplexes a broad range of plesiochronous and synchronous signals into 2.5 Gbit/s (STM-16), 622 Mbit/s (STM-4) or 155 Mbit/s (STM-1). The method used to map Interface signals complies with the AU-4 mapping procedure specified by ITU-T. STM-1 and STM-4 optical tributary boards also support AU-3 mapping for some interface signals.

The system can be used as an add/drop multiplexer, terminal multiplexer or small local cross-connect (see Chapter 4). It provides built-in cross-connect facilities and flexible interface circuit packs. Local and remote management and control facilities are provided via the Q and F-interfaces and the Embedded Communication Channels. The cross-connect circuit pack is the core of the WaveStar® ADM 16/1 system.

An outline of the basic WaveStar® ADM 16/1 architecture is given in Figure 1-1.

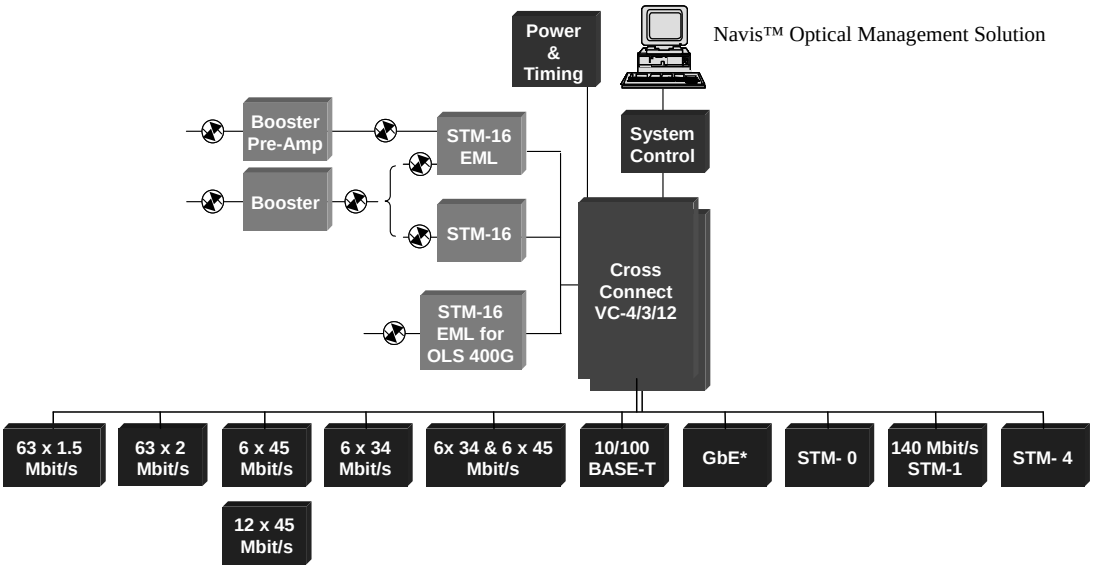

Figure 1-1. Basic architecture WaveStar® ADM 16/1 System

Cross-connect

The cross-connect is the core of the WaveStar® ADM 16/1 system. The cross-connect circuit pack functionally consists of two parts: a higher and a lower order cross-connect, although physically the cross-connect circuit pack is a single circuit pack.

The higher order cross-connect switches VC-4s and its capacity is 64 x 64. Other functions of the higher order cross-connect are: VC-4 SNC protection switching, MS SPRing protection, MSP, equipment protection (see Chapter 2 for detailed explanations of mentioned protection mechanisms), non-intrusive monitoring of VC-4s and broadcasting.

The lower order cross-connect switches/grooms VC-3 and VC-12s and its capacity ranges up to 2016 x 2016 VC-12s equivalents or 32 x 32 VC-4s. Other functions of the lower order cross-connect are: lower order SNCP protection, non-intrusive monitoring of lower order-VCs and lower order broadcasting.

Tributary and line interfaces circuit packs are directly connected to the higher order cross-connect via STM-1 equivalent signals.

Higher order and lower order cross-connect parts are interconnected via an internal cross-connect-bus of 32 bi-directional VC-4s wide. The lower order cross-connect itself is uni-directional, although traffic is switched/protected bi-directionally.

Higher order VC-4s arriving from line or tributary circuit packs need only to be routed through the lower order matrix, if the lower order VC content needs to be groomed. Otherwise, the VC-4 can be routed through the higher order cross-connect only!

Flexible routing and cross-connecting of VC-4, VC-3 and VC-12 between line port ⇔ line port, Line port ⇔ tributary port and tributary port ⇔ tributary port is possible.

The system architecture makes it possible to use an interface circuit pack in almost any other slot position, hence the system becomes very flexible. A broad range of applications can be served with the same shelf based on a common software platform.

To contribute to overall system reliability and availability, the cross-connect circuit pack can be 1 + 1 equipment protected by an accompanying circuit pack.

Fixed cross-connect

The fixed cross-connection unit replaces the (working) cross-connect unit to provide a 0:1 or 0:2 terminal configuration, in which the (16) VC-4s of four tributary units are routed towards one line port unit and the (16) VC-4s of four other tributaries are routed towards the other line port unit.

Interface circuit packs

The WaveStar® ADM 16/1 supports a large variety of Interface circuit packs: 1.5, 2, 34/45, 51.8,140/155, 622 Mbit/s and 2.5 Gbit/s are the bit-rates that are supported. For Ethernet support a tributary interface is available supporting 10/100 Mbit/s Base-T. If

required, interface redundancy can be provided (excluding 10/100 Mbit/s Base-T). For details of these circuit packs, please refer to ‘circuit packs’ described in Chapter 4.

System control and network management

The system controller (SC) controls and provisions all circuit packs via a local LAN bus. The SC also provides the external operations interfaces for office alarms, miscellaneous discretes and connections to the overhead channels (a maximum of six overhead bytes may be selected to be connected to six connectors on the interconnection panel.

The SC also facilitates first line maintenance by several LEDs and buttons on the front panel. General status and alarm information is displayed. Various controls and an F-interface connector, for a local maintenance PC (ITM-CIT), are also located on this panel.

The SC communicates with the centralized management system (WaveStar® ITM-SC and Navis™ Optical NMS).

A part of the SC, routing management information between SDH equipment and the element management system, is called data packet switch (DPS). Communication is established via so-called data communication channels (= D1-3/D4-12 bytes) (DCC), within the STM-N section overhead signals or via one of the Q-interfaces of the system. Information destined for the local system is routed to the System Controller, while other information is routed from the node via the appropriate embedded channels of the STM-N line or tributary signals.

The WaveStar® ITM-SC manages the WaveStar® ADM 16/1 at the element level and the Navis™ Optical NMS manages the system at the Network Level. The ITM-Craft interface terminal (ITM-CIT) can be used for managing single network demands and for maintenance.

Power and Timing

In addition to the transmission and control functions briefly described above, the WaveStar® ADM 16/1 can be equipped with one or two power and timing circuit packs (PT). These power and timing circuit packs provide power and timing to the system. To contribute to the overall system reliability and availability, the power and timing circuit pack can be 1 + 1 equipment protected by an accompanying circuit pack.

Power

A basic function of the PT circuit pack is to filter and stabilize the incoming station power to meet the necessary ETSI requirements. The basic power distribution philosophy throughout the WaveStar® ADM 16/1 is to equip each circuit pack with on-board DC/DC converters that convert the secondary (station battery) voltage to the voltages required for each circuit pack. The power feed from the station battery voltage is maintained duplicated throughout the system’s backplane.

Timing

Another basic function of the PT is system timing. The local oscillator, also called the SDH Equipment Clock (SEC), can be synchronized to one of the user-selectable timing references. There are two types of PT circuit packs available: one so-called standard PT with a standard holdover stability and one with a more accurate holdover stability frequency; Stratum-3 (see circuit packs in Chapter 4 for more details).

Features and Benefits

2

Overview

This chapter briefly describes the features and benefits of the WaveStar® ADM 16/1. These features are further described in Chapter 3, “Applications”, Chapter 4, “Product Description” and Chapter 5, “Operation, Administration, Maintenance and Provisioning” as applicable.

Standards Compliance

Lucent Technologies SDH products comply with the relevant SDH ETSI and ITU-T standards. Important functions defined in SDH Standards such as the data communications Channel (DCC), the associated 7-layer OSI protocol stack, the SDH multiplexing structure and the Operations, Administration, Maintenance, and Provisioning (OAM&P) functions are implemented in the Lucent Technologies product family.

Jitter standards are also incorporated, guaranteeing a smooth interworking between PDH and SDH based networks. The full benefits of the SDH Standards are provided while preserving the integrity of the existing plesiochronous network.

Lucent Technologies is closely involved in various study groups with ITU-T and ETSI that focus on creating and maintaining the latest global SDH standards. The WaveStar® ADM 16/1 complies with all relevant ETSI and ITU-T standards and is kept up to date according to the latest standards.

Features and Benefits

One of the main features of the WaveStar® ADM 16/1 is its ability to add/drop and flexibly cross-connect 2 Mbit/s directly from the STM-16 level (ADM 16/1). Other signals that can be add/dropped are: 1.5 (DS-1), 34 (E3), 45 (DS-3), 51.8 (STM-0), 140 (E4), 155 (STM-1), 622 Mbit/s (STM-4), 18x GbE interfaces (Gigabit Ethernet) and 10/100 Base-T (Ethernet).

Summary of main Features and Benefits:

Described in this Chapter:

- Protection mechanisms supported: MS SPRing, higher order & lower order SNC/N, MSP, Dual Node Interworking (DNI).
- Synchronization and Timing:
  - Support of ETSI synchronization message protocol (Timing Marker)
  - Support of various synchronization modes, including 2 Mbit/s tributary timing.
- AU-4 / TU-3 to AU-3 conversion on STM 1 and STM-4 optical interfaces
- Integrated optical booster and booster/pre-amplifier
- Remote maintenance and management by Lucent Technologies Navis™ Optical Management Solution (WaveStar® ITM-SC and Navis™ Optical NMS)
- Installation practice.

Described in Chapter 3, Applications:

- STM-16, STM-4, STM-1 point-to-point (end) terminal connections. Options are: 0x1 terminal with no line protection and 1+1 MSP line-protected terminal
- STM-16, STM-4, STM-1 two fiber add/drop terminal in linear applications and rings
- Hubbing functionality
- Small cross-connect
- Broadcasting functionality
- Payload concatenation:
  - Virtual Concatenation on WaveStar® TransLAN™ Card
  - Interconnecting ATM systems via VC-4-4c concatenation
- Tributary interface mixing
- Single ADM for interconnection of STM-16, STM-4 and STM-1 rings (ring closure)
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- Multi-Service applications with WaveStar® TransLAN™ Card.

Dual node interworking with drop and continue. Described in Chapter 4, System Description:

- Equipment redundancy (all electrical interfaces, cross-connect, line port unit and power and timing unit).
- Maximum Add/Drop capacity per shelf.VC-4, VC-3 and VC-12 Bi-directional cross-connect capability
- 0:1 and 0:2 terminal application with fixed cross-connect
- Full Time Slot Assignment (TSA) for port interface signals and Time Slot Interchange (TSI) for through-channels
- Mixing/Grooming of various payload types.

Protection mechanisms

The WaveStar® ADM 16/1 Multiplexer and Transport system provides the following types of network level automatic transmission protection:

- Point-to-Point Multiplex Section Protection (MSP)

  A 1+1 MSP protection relation can be set up between a pair of STM-0 optical tributary interfaces. The applied protocol is according to ITU-T Recommendation G.841/Annex B, supporting non-revertive operation with bi-directional control.

  A 1+1 MSP protection relation can be set up between a pair of STM-1 or STM-4 optical tributary interfaces. The applied protocol can be selected per interface according to G.841/clause 7 supporting:

  - revertive and non-revertive operation
  - uni-directional and bi-directional control

  or to G.841/Annex B supporting:

  - non-revertive operation
  - bi-directional control.

  In addition, for these interface types interworking with SONET type MSP is supported in non-revertive opeartion with uni-directional control.

  A 1+1 MSP protection relation can be set up between the STM-16 aggregate interfaces. The applied protocol is according to G.841/clause 7. It supports both revertive and non-revertive operation and both uni-directional and bi-directional control.

  See also Chapter 3.

- VC-n SNC/N protection switching.

  Sub-network connection protection switching is selectable per VC using non-intrusive monitoring (SNC/N). This protection switching facility is non-revertive.

  The VC-n SNC protection scheme is in essence a 1+1 point-to-point protection mechanism. The head end is dual fed (permanently bridged) and the tail end is switched. The switching criteria at the tail end are determined from the server layer defects in combination with the non-intrusive monitoring information.

  SNC protection can be applied per individual VC-pair, for lower-order VCs the total number of VCs that can be SNC protected is limited only by the lower order cross-connect size (See Chapter 5).

  SNC/N protects against:

  - Server failures
  - Open matrix connections (“unequipped signal”)

- An excessive number of bit errors (“signal degrade”)
- Misconnections (“trail trace identifier mismatch”).

- Multiplex section shared protection ring protocol (MS-SPRing)

  In two fiber add/drop ring applications, the VC-4s on the STM-16 ring can be protected by the MS-SPRing protection mechanism. Rings protected by MS-SPRing can have a maximum of 16 nodes. Within STM-16 MS-SPRing, channel #1 is protected by channel #9, #2 by #10, etc. upto #8 protected by #16. Each channel can be included in or excluded from the MS-SPRing protection mechanism. Access to the protection channel capacity for “extra, low-priority traffic” is supported.

- Dual node interworking (DNI) with drop and continue (D&C).

  The DNI with D&C scheme protects the interconnection between two subnetworks within which the traffic is already protected by a network protection scheme. The advantage of using DNI protection in a network is that there are no single point of failures anymore.

  DNI is supported in the following cases:

  - between two MS-SPRing protected STM-16 rings.
  - between a MS-SPRing STM-16 ring and a lower order SNCP protected subnetwork.

  From the Sapphire release and onwards, sub-networks without DNI protected interconnections can be upgraded in-service to have DNI protected interconnections.

The WaveStar® ADM 16/1 supports the cascading of two protection schemes in one network element without needing multiple passes through cross-connects. The following schemes are cascadable:

- MS-SPRing or MSP on aggregates and MSP on tributaries.
- MS-SPRing or MSP on aggregates and LO-SNCP or HO-SNCP.
- Two identical VC-n SNCP sections.
- Two SNCP schemes on the same or different VC-n level.

Synchronization and Timing

Several synchronization configurations can be used, the WaveStar® ADM 16/1 can be provisioned for:

- Free-running operation
- Hold-over mode
- Locked mode, internal SDH Equipment Clock (SEC) locked to:
  - One of the external sync inputs (2048 kHz or 2048 kbit/s)

- One of the 2 Mbit/s tributary signals
- One of the STM-N inputs (line or tributary port).

The user can select the external synchronization output to be locked to a suitable input signal independently of the selection made for the internal oscillator.

Frequency Offset Handling

By comparing the frequencies of all assigned references with the frequencies of the internal oscillator on both timing units, it can be decided, in case an excessive frequency difference is detected, whether a reference is off-frequency on the internal oscillator of one of the timing units. In that case that unit is declared failed.

Timing Reference protection

The external timing references are non-revertively 1+1 protected. The external timing references can also operate unprotected.

Timing Mode protection

If the primary timing reference fails, the system will automatically switch over to the holdover mode. The synchronization status message is supported which enables timing reference priority settings and gives information about the timing-signal quality.

Synchronization Status Message support

A timing marker or synchronization status massage (SSM) signal can be used to transfer the signal quality level throughout a network. This will guarantee that all network elements are always synchronized to the highest quality clock available.

On the WaveStar® ADM 16/1 system the SSM algorithm or timing marker is supported according to G.781. SSM is supported on all STM-N interfaces and on the 2 Mbit/s synchronization output signal (connected to the station output clock).

2 Mbit/s tributary retiming

The user can choose for individual 2 Mbit/s tributary outputs to operate “self-timed” or “re-synchronized”. In the (standard) self-timed mode, the phase of the outgoing signal is a moving average of the phase of the 2 Mbit/s signal as it is embedded in the VC-12 that is disassembled. In the re-synchronized mode the 2 Mbit/s signal is timed by the SDH Equipment Clock (SEC) of the network element; phase differences between the local clock and the 2 Mbit/s embedded in the VC-12 to be disassembled are accommodated by a slip-buffer.

There is an option that whenever the traceability of the local clock drops below a certain threshold; the re-timing 2 Mbit/s interfaces automatically switch to self-timing and vice-versa when the fail condition disappears, without hits in the traffic.

AU-3 / TU-3 conversion

Tributary circuit packs (SPIA-1E4/4B or SIA-1/4B) are available for supporting the connection of STM-1 optical, AU-3 structured, signals to the WaveStar® ADM 16/1 system. A maximum of four STM-1 optical signals is supported per circuit pack.

Because the cross-connect supports AU-4 structured signals, a translation from AU-3 to TU-3s needs to take place. This functionality is located on the circuit pack. Besides AU-3 to TU-3 translating mode this tributary card can also operate in the AU-4 mode. The circuit pack fits into a single freely selectable tributary slot of the system.

This circuit pack can function in either mode, depending on the traffic type on the tributary interface (AU-3 or AU-4 based) and the cross-connect circuit pack.

A converter circuit pack (named SA-0/12) is available supporting connection of STM-0 optical, AU-3 structured signals to AU-4 structured signals needed by the cross-connect of the WaveStar® ADM 16/1 system. A maximum of twelve STM-0 optical signals is supported per circuit pack.

Similar to the STM-1 optical tributary card also the STM-4 optical card supports AU-3 to TU-3s conversion. One STM-4 optical card supports one interface.

Integrated optical booster and booster pre-amplifier

For ultra long distance applications (160 km per ITU-T G.692 U-16.2/3) an optical booster and a pre-amplifier must be connected to the STM-16 optical interface. For very long distance(120 km) a booster-only pack can be used. A combined optical booster and booster pre-amplifier circuit pack uses one of the slots reserved for the Interface circuit packs (see Chapter 8).

Remote maintenance, management and control by Lucent Technologies Navis™ Optical Management Solution Two-Tier Maintenance

The WaveStar® ADM 16/1 System maintenance procedures are built on two levels of system information and control. The first maintenance Tier consists of the user panel display (LEDs) and push buttons (all on the front of the system controller), and the circuit pack faceplate light-emitting diodes (LEDs). These allow most typical maintenance tasks to be performed without the ITM-Craft Interface Terminal (ITM-CIT) or element manager (WaveStar® ITM-SC).

The second maintenance tier employs Lucent Technologies' Navis™ Optical Management Solution. Detailed information and system control are obtained by using the ITM-CIT (Craft Interface Terminal), which supports provisioning, maintenance and configuration on a local basis. A similar facility is (via a Q-LAN connection or via the DCC channels) remotely available on the element manager, the WaveStar® ITM-SC, which provides a centralized maintenance view and supports maintenance activities from a central location.

At network level (customer's network management center), Lucent Technologies' Navis ™ Optical Management Solution system performs all the tasks necessary to supervise, operate, control and maintain an SDH network with the WaveStar® ADM 16/1.

Operations Interfaces

The WaveStar® ADM 16/1 Multiplexer System offers a wide range of operations interfaces to meet the needs of an evolving operations system (OS) network. The operation interfaces include:

- Office Alarm Interfaces:

  This interface provides a set of discrete relays that control office audible and visible alarms.

- User-settable miscellaneous discrete interfaces:

  This interface provides 8 user-selectable miscellaneous discrete inputs and 4 control outputs. These miscellaneous discrete inputs and outputs can be used to read the status of external alarm points and to drive external devices.

- Two local workstation F interfaces:

  Two F interfaces are provided, one at the front (on the faceplate of the SC) and one at the rear of the WaveStar® ADM 16/1. These interfaces provide operation access for a PC-based workstation also known as a Craft Interface Terminal (ITM-CIT). It can be operated by a crafts person working in front of the system or at the rear, but not at the same time.

- Q interfaces

  The Q-interfaces enable network-oriented communication between WaveStar® ADM 16/1 systems and the element / network Manager. This interface uses a Qx interface protocol compliant with ITU-T recommendation G.773-CLNS1 to provide the capability for remote management via the data communication channels (DCC).

  Two types of Q interface are available:

  - Q LAN 10 base T (Twisted Pair Ethernet, for twisted pair cables)
  - Q LAN 10 base 2 (Thin Ethernet or CheaperNet, for 2 coaxial cables)

Single-Ended Operations by WaveStar® ITM-SC

The WaveStar®ITM-SC Element Manager provides single-ended operations capability by remotely accessing all the WaveStar® ADM 16/1 systems in a network from a single location. Operation, administration, maintenance and provisioning can be performed on a centralized location.

Local and Remote Software Upgrades

The WaveStar® ADM 16/1 System provides the capability to upgrade the system software in service without requiring any control circuit pack changes. The system monitoring and control are fully functional during the software download. Software is downloaded locally using the local ITM-CIT or remotely from the element manager via the Data Communication Channel (DCC).

Local and Remote Inventory capabilities

The WaveStar® ADM 16/1 System provides automatic version recognition of all hardware and software installed in the system. Circuit pack types and circuit pack codes ('comcodes') are accessible via the local ITM-CIT or via the WaveStar® ITM-SC Element Manager. This greatly simplifies troubleshooting, dispatch decisions, and inventory audits.

Installation practice

The WaveStar® ADM 16/1 is housed in a self-supporting single-row shelf to fit in standard ETSI racks of 600 mm depth and width. A maximum two WaveStar® ADM 16/1 shelves fit in one 2200 mm high ETSI rack cabinet (HxWxD = 2200 x 600 x 600 mm), 2600 mm high ETSI rack cabinet (HxWxD=2600 x 600 x 600) or 2000 mm earthquake-proof rack cabinet (HxWxD=2000 x 600 x 600). The dimensions of the WaveStar® ADM 16/1 shelf are: 750 x 500 x 545 (HxWxD) mm.

Installation restrictions can be found in Chapter 7 (cabling the WaveStar® ADM 16/1).

Ethernet LAN connection

The WaveStar® ADM 16/1 provides a LAN Ethernet tributary board, based on the WaveStar® TransLAN™ Card, which can provide a simple, managed solution for multiple-site LAN interconnection. By mapping Ethernet frames into VC-12-xv (x=1,2...5) or VC-3-xv (x=1,2) the WaveStar® ADM 16/1 can support 10/100Base-T Ethernet connections, and provide the integrated data connection within the SDH network.

The main features of TransLAN™ are:

- Ethernet LAN tributary board is according to IEEE 802.3 Ethernet
- Ethernet frames are mapped into VC-12-xv (x=1,2...5) or VC-3-xv (x=1,2):
  - VC-12-xv (x=1...5) means 2Mbit/s, 4Mbit/s, 6Mbit/s, 8Mbit/s, 10Mbit/s
  - VC-3 and VC-3-v2 mean 50Mbit/s and 100Mbit/s
- Multiple Operation Modes:
  - Repeater Mode for point to point operation
  - LAN-Interconnect Mode, dedicated WAN bandwidth for single end-user
  - LAN-VPN Mode, LAN Ports of multiple end-users share the same WAN port(s) bandwidth
  - LAN-VPN with IEEE 802.1p QoS Mode
  - Spanning Tree Virtual Switch Mode with IEEE 802.1Q VLAN Tagging
- Ethernet/Fast Ethernet VLAN Trunking based on IEEE 802.1Q VLAN Tagging
- GVRP according to IEEE 802.1Q, automatic provisioning of VLAN ID in intermediate nodes

- Spanning Tree Protocol , compliant to IEEE802.1D and IEEE802.1s, eliminates loops in bridged network

The main benefits of WaveStar® TransLAN™ Card are:

- Scalable bandwidth without having to change interface, by using 10/100BaseT interface, customer can choose the VC-12-xv (x=1,2,..5) and VC-3-xv (x=1,2) and get the required bandwidth at 2,4,8,10,50 and 100Mbit/s.
- A transparent LAN service that hides the complexity of the WAN for end users (a WAN that looks like a LAN)
- WAN access interface can be shared by other end-customers in a multi-tenant building environment
- Provide end-to-end QoS (bandwidth, reliability) guaranteed when VPN path traveling through multiple network platforms (FR, ATM, IP)
- Provide end-to-end interworking between VPN routers in a multi-vender environment.
- High-availability LAN service by using end-to-end SDH protection switching
- Increases revenue opportunities with packet service integration into SDH based network
- Reduce cost of ownership by avoiding a seperate overlay data network.
- With VLAN trunk feature WaveStar® TransLAN™ cards can hand off end user LAN traffic via one high capacity LAN port instead of multiple low speed LAN ports, thus reducingport, space and cabling costs

Applications

3

Overview

The WaveStar® ADM 16/1 is a single, highly flexible product that supports a variety of STM-16 network applications.

Based on its flexibility with regard to Interface circuit packs and cross-connect capabilities (see Chapter 4) the system supports a wide range of applications for bandwidth access, service-on-demand and network protection.

The WaveStar® ADM 16/1 can be applied in all three tiers of a network, that is: Access, Regional and Backbone. The system allows for growth and changing service needs by supporting in-service conversions and upgrades. Inherent to its basic design, the system operates equally well within fully synchronous as a-synchronous environments and provides a flexible link between the two.

The WaveStar® ADM 16/1 supports a large variety of configurations for various network applications:

- STM-16, STM-4, STM-1 point-to-point (end) terminal connections. Options are: 0x1 terminal with no line protection and 1+1 MSP line-protected terminal
- STM-16, STM-4, STM-1 two fiber add/drop terminal in linear applications and rings
- Hubbing functionality
- Small cross-connect
- Broadcasting functionality
- Payload concatenation:
  - Virtual Concatenation on WaveStar® TransLAN™ Card
  - Interconnecting ATM systems via VC-4-4c concatenation
- Tributary interface mixing
- Single ADM for interconnection of STM-16, STM-4 and STM-1 rings (ring closure)
- Dual node interworking (DNI) with drop & continue

- SONET-SDH Conversion and Interworking
- Multi-Service applications with WaveStar® TransLAN™ Card, supporting 10/100 BASE-T and 1000BASE-X Ethernet.

STM-16 Point-to-Point (End) Terminal Application

The WaveStar® ADM 16/1 Multiplexer and Transport System can be configured to provide an STM-16, STM-4, STM-1 point-to-point application (see figure 3-1).

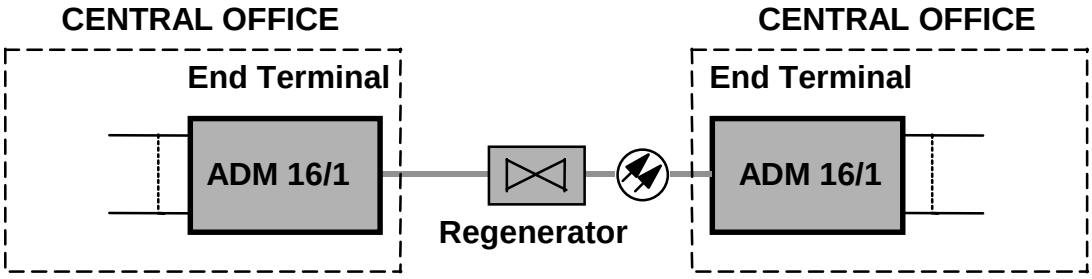

Figure 3-1. WaveStar® ADM 16/1 0 x 1 End Terminal STM-16 Point-to-Point Application

The STM-16, STM-4 or STM-1 point-to-point application is served by two 0x1 end terminals (Each terminal one transmit/receive circuit pack).

The regenerator can be used to increase the distance between the terminals. The regenerators can be maintained through the end terminals at either span or through a modem at the repeater side. To span longer distances without using the Regenerators in intermediate nodes, the user can also make use of the in-shelf optical booster/pre-amplifiers available for the WaveStar® ADM 16/1

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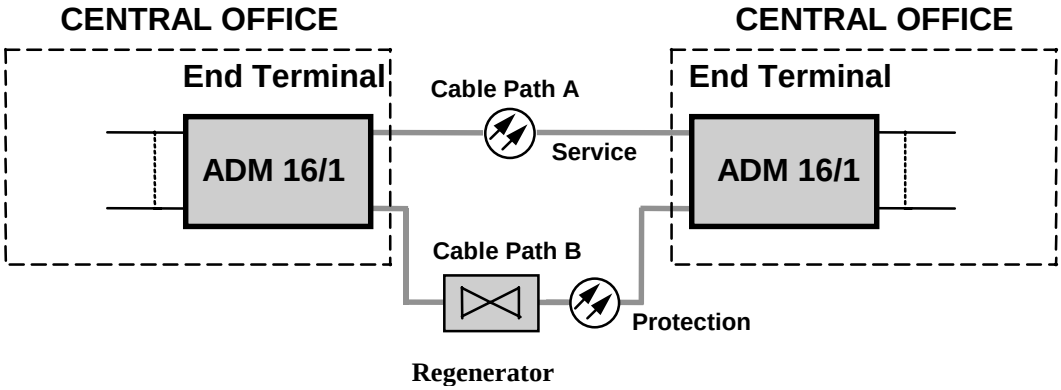

Figure 3-2. WaveStar® ADM 16/1 1+1 MSP Protected End Terminal, STM-16 Point-to-Point Application

The WaveStar® ADM 16/1 Multiplexer and Transport System can be configured to provide an STM-N (N=16, 4, 1) 1+1 MSP protected point-to-point application (see figure 3-2).

The STM-N (N=16, 4,1) 1+1 MSP point-to-point application is served by two WaveStar® ADM 16/1 end terminals. These terminals are equipped with each two STM-N lines, one for service and one for protection. Each STM-N line consist of a pair of single mode fibers (one transmit, one receive).

The system uses revertive or non-revertive protection switching, this means:

- In revertive operation, the traffic is switched from the working to the protection line if a fault occurs. In this case low priority traffic, if connected, is automatically switched off. When the fault clears, the traffic is automatically switched back (revertive) to the working line.
- In non-revertive operations the traffic is switched from the working to the protection line, if a fault occurs. In this case low priority traffic, if connected, is automatically switched off. When the fault clears, the traffic is not automatically switched back (non- revertive reverts) to the working line.

STM-16 two fiber Add/Drop Terminal in linear applications and rings

The WaveStar® ADM 16/1 two fiber add/drop terminal is a flexible product that can be used for ring and non-ring applications, for example point-to-point linear applications. Linear applications can be ‘upgraded’ to conventional rings.

ADM-16 in Linear applications

Figure 3-3 shows the WaveStar® ADM 16/1 add/drop terminal used in a linear application. Both end-nodes are WaveStar® ADM 16/1 systems functioning as a 0x1 Terminal and the two intermediate nodes are ADMs. There is no route diversity.

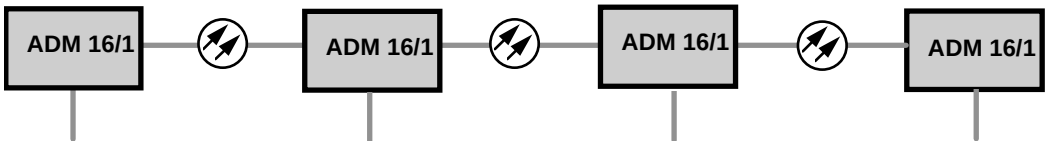

Figure 3-3. WaveStar® ADM 16/1 Linear Add/Drop Application

Folded or collapsed rings

Folded rings are rings without fiber diversity. This is in fact a linear application of the WaveStar® ADM 16/1. The terminology derives from the image of folding a ring into a linear segment.

Folded or collapsed rings can be created by using the WaveStar® ADM 16/1. Sometimes this configuration is also called a ‘flattened ring’

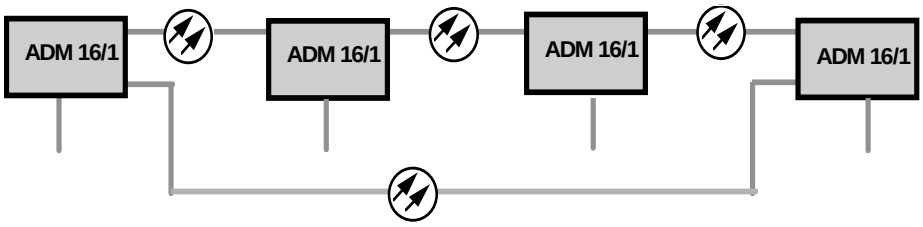

Figure 3-4. WaveStar® ADM 16/1 ‘Folded or Collapsed Ring’ Application

The WaveStar® ADM 16/1 two fiber add/drop terminals enable the user to use folded rings in a variety of “non-ring” applications, such as linear add/drop topologies. Folded

rings provide flexibility and can help evolve the network into a fully (conventional) ring configuration.

In the folded-ring configuration shown in figure 3-4, terminals are placed at adjacent nodes, and the end nodes are connected together across the whole network.

In a folded ring, all facilities are run in the same path, for example, a cable sheath between the nodes. Therefore, in the case of a facility or node failure, nodes on each side of the failure are isolated, as in the linear add/drop chain. Because the length of the network is probably long and the optical loss greater than the system gain of the transmitter/receiver pairs, there may be a need to use intermediate repeaters or intermediate ring nodes (ADMs) on the return path to connect the end nodes.

ADM-16 in ring applications

Rings provide redundant bandwidth and/or equipment to ensure system integrity in the event of any transmission or timing failure, including a fiber cut or node failure. A ring is a collection of nodes that form a closed loop, in which each node is connected to adjacent nodes. Ring nodes can be made up of the WaveStar® ADM 16/1 two fiber add/drop terminals.

The WaveStar® ADM 16/1 two-fiber add/drop terminal supports two-fiber, bi-directional, line switched rings working at STM-16, STM-4 or STM-1 level. At STM-16 level the MS-SPRing protection mechanism is supported. SNCP is supported at all other levels (see figure 3-5).

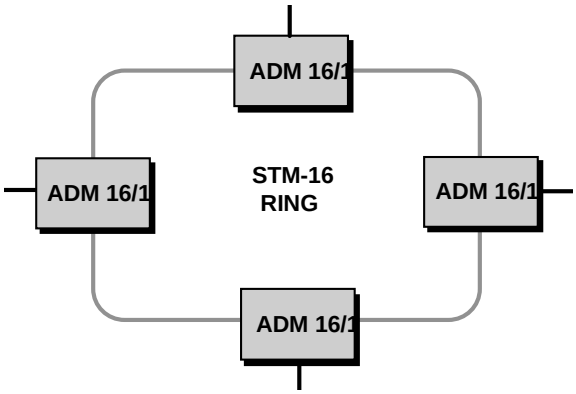

Figure 3-5. The WaveStar® ADM 16/1 ring application

One of the most cost-effective applications of the WaveStar® ADM 16/1 is an add/drop terminal functioning at a line speed of 2.5 Gbit/s and dropping traffic at tributary speeds of 2 Mbit/s. Per network element, up to 504 x 1.5 Mbit/s, 504 x 2 Mbit/s, 48 x 34 Mbit/s, 96 x 45 Mbit/s, 96 x STM-0, 32 x 140 Mbit/s, 64 10/100Base-T, 32 x STM-1 or up to 8 x STM-4 can be add/dropped directly from the STM-16 level.

When using the already mentioned MS-SPRing protection mechanism, rings from 2 up to 16 nodes are supported (the maximum allowed by the standard). They perform automatic protection switching (revertive) in less than 50 msec.

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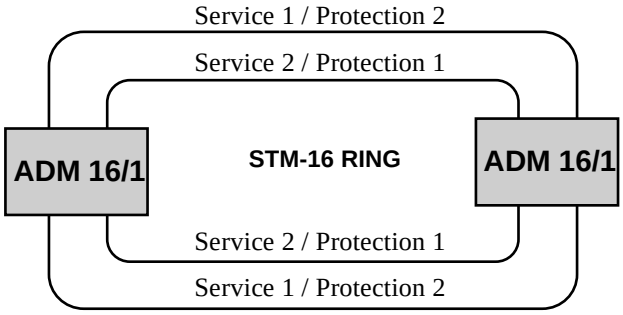

Figure 3-6. MS-SPRing protected STM-16 Rings with WaveStar® ADM 16/1

In bi-directional line-switched rings under normal conditions, service traffic and protection traffic travel in both directions around the ring. Given spans consist of two sets of bi-directional channels: service channels and protection channels. Each physical line is shared by service channels and protection channels. See Figure 3-6.

Upgrading a folded ring to a conventional ring

In a linear Add/Drop topology, folded rings provide flexibility in the amount of equipment deployed. In many cases a network starts out as a linear Add/Drop chain because of short-term service needs between some of the nodes. It then evolves into a ring later when there is a need for service and fiber facilities to other nodes in the network. It is easier to evolve the linear Add/Drop network into a full ring configuration if a folded ring is used in the nodes that have this short-term service.

Folded rings have upgrade, operational, and self-healing advantages over other topologies for this type of evolution.

Deploying folded ring technology to evolve a ring network from a linear Add/Drop chain configuration to a full ring network provides the following advantages:

- A folded ring can be more easily upgraded (that is, in-service) to include the new node in a full ring configuration than in back-to-back or linear add/drop configurations.
- A folded ring familiarizes users with the operation, administration, maintenance, and planning (OAM&P) of a ring.
- In most cases, a folded ring is more cost-effective than deploying back-to-back or linear Add/Drop configurations.
- A folded ring can recover from some Terminal failures better than a linear Add/Drop chain.

See Figure 3-7 for an upgrade example.

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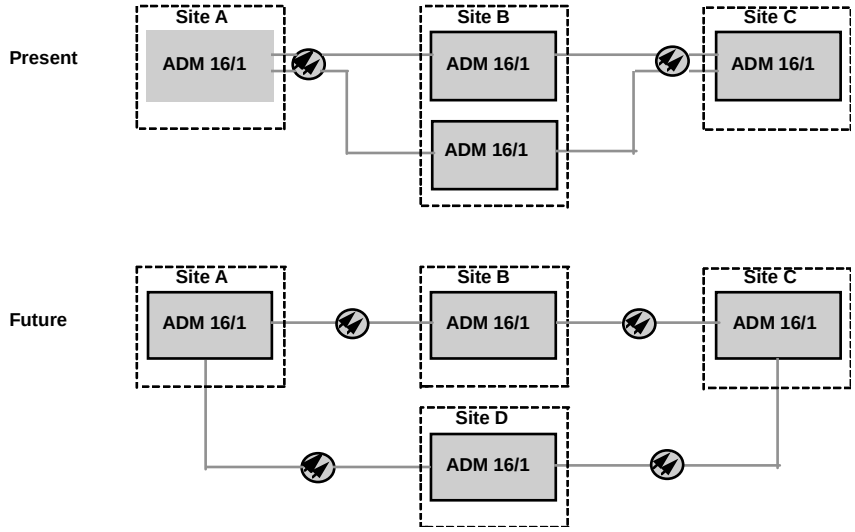


Figure 3-7. Upgrade 'Folded Ring' to conventional ring

Hubbing functionality

The WaveStar®ADM 16/1 system can be configured to function as a hub-terminal at STM-16 level by deploying the WaveStar® ADM 16/1 as an end terminal or add/drop terminal.

The WaveStar® ADM 16/1 can serve a cluster of for instance WaveStar® ADM 4/1 multiplexers and WaveStar®AM 1 (Plus) multiplexers located at remote sites (see Figure 3-8). In this way, the WaveStar® ADM 16/1 Systems can be configured as an STM-16 hub. All the traffic for the WaveStar® ADM 4/1 Multiplexers passes through the hub using either these electrical or optical interfaces.

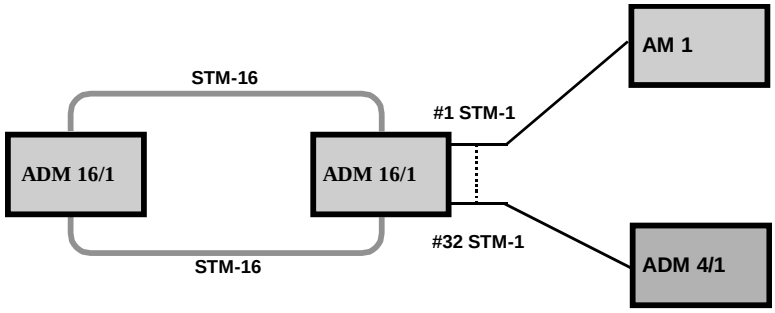


Figure 3-8. Example of a HUB Terminal configuration

Small cross-connect

The WaveStar® ADM 16/1 system can be used to function as a small local cross-connect system. At VC-4 level, a maximum cross-connect capacity of **64 x 64** is available. For lower order VCs (VC-3 and VC-12s) a maximum of **32 x 32** VC-4s may be opened at any time for grooming purposes.

This means that within a single shelf e.g. a VC-4, 3, 12 cross-connect can be realized to cross-connect a maximum of 64 x STM-1 equivalents. A maximum of 32 x VC-4s can be groomed in the lower order cross-connect (see Chapter 4).

64 x STM-1 equivalents can be connected with the higher order cross-connect as follows: 16 x STM-1s derived from East and 16 x STM-1s derived from the West side of the cross-connect, plus 32 x STM-1s (8 slots times four STM-1s per circuit pack) from the tributary side. Hence, in total 64 STM-1 equivalent signals are connected to the higher order cross-connect and can be cross-connected at VC-4 level. When the contents of some of these VC-4s needs to be groomed or Time Slot Interchanged (TSI), a maximum of 32 x bi-directional VC-4s can be connected to the lower order cross-connect for this purpose. Cross-connections can be set bidirectionally.

Broadcasting functionality

The WaveStar® ADM 16/1 has broadcast functionalities for VC-12, VC-3, VC-4 and VC-4-4c containers. There are two broadcast modes possible, controlled by either the ITM-CIT or the WaveStar® ITM-SC:

- Uni-directional 1:N broadcast

  A particular incoming VC is retansmitted in multiple (N = 2 .. 9) directions. The return channels remain unused without generating any alarms.

- 1:2 broadcast

  This is meant for test purposes. One of the directions of a bi-directional signal is broadcasted to an unused system output

- Uni-directional 1:N broadcast with protection

  The system supports unidirectional cross-connects at the VC-4, VC-4-4c, VC-3 and VC-12 level in ring or linear networks, such that up to nine copies of a VC-n can be dropped (broadcasted) uni-directionally to tributary ports from a bi-directional transit VC-n. The go- and return directions of this transit VC-n are usually identical. SNC/N selectors determine which direction of the transit signal is dropped towards each tributary port. This feature is to support protected video distribution networks.

Setting up or breaking down a broadcast direction does not affect the traffic in the other branches.

Payload Concatenation

Within the SDH standards there are two methods defined to create larger payload capacity than provided by a single VC-12 (payload capacity: 2.176 Mbit/s), VC-2 (6.848 Mbit/s), VC-3 (53.760 Mbit/s) or VC-4 (149.760 Mbit/s). These methods are called “virtual concatenation” and “contiguous concatenation”. In both cases multiple VC’s are taken together to create a bigger capacity transport pipe.

Virtual concatenation

In the case of virtual concatenation, the payload is divided over multiple VC’s, which are independently transported through the SDH network. The total transport entity in called VC-n-Xv, where the n is indicating the VC-type (n = 12, 2, 3 or 4) and the X is denoting the number of VC’s that are taken together to form a virtually concatenated signal. The v stands for “virtual”.

Each VC-n that is part of a VC-n-Xv structure has its own path overhead and its own corresponding TU-pointer, so each VC-n is transported independently over the SDH network between the VC-n-Xv termination points. The most popular options being considered are VC-12-Xv (X = 2,.., 63) and VC-2-Xv (X = 2,.., 21). For transport of these VC-n-Xv types it is required that all participating VC-n’s are located in the same VC-4. On the WaveStar® ADM 16/1 virtual concatenation is used on the Ethernet LAN tributary card which is based on the WaveStar® TranLAN™ Card. On the Ethernet LAN tributary board Ethernet frames are mapped into VC-12-xv (x=1,2...5) or VC-3-xv (x=1,2).

Contiguous concatenation

Contiguous concatenation is only applicable at the VC-4 level. In this case the payload is divided over multiple VC4’s which are carried over the network as a single block, where the VC-4’s are mapped in adjacent AU-4 envelopes. This contiguous group of VC-4’s has only one single column of path overhead and also has a single pointer, which controls the phase of the complete block. Contiguously concatenated VC-4s are denoted as VC-4-Xc (X = 4, 16 or 64). The “c” indicates the fact that “contiguous” mapping is used.

To transport VC-4-Xc payloads through the SDH network, it is necessary that all SDH nodes that are passed through support this mapping. The WaveStar® ADM 16/1 supports transport of VC-4-4c (payload capacity: 599.040 Mbit/s) via the STM-16 aggregate interfaces and STM-4 tributary interfaces. The VC-4-4c payload can be added or dropped via the STM-4 tributary. In addition, protection of VC-4-4c is supported within the MS-SPRing protection scheme in an STM-16 ring. Also, SNC/N protection is supported to protect the add/drop path via the tributaries or in case MS-SPRing is not used. Lastly, passing VC-4-4c’s can be non-intrusively monitored, both for faults and performance.

Tributary interface mixing

The WaveStar® ADM 16/1 Multiplexer and Transport System supports a mix of 1.5, 2, 34, 45, 10/100 Base-T Ethernet, STM-0, 140, STM-1 and STM-4 tributary speed interface inputs and outputs. It is possible to mix these interfaces in the same subrack for all platforms. Also, a circuit can enter a WaveStar® ADM 16/1 network through one type and exit through another type (if the payload that is being carried is compatible with both interface types). Mixing is supported not only within a Terminal, but also between Terminals.

These capabilities offer more efficient network evolution and allow planners to improve their equipment deployment based on the needs of the particular Application. For example, network needs (sudden demand) may require SDH deployment in one area before others.

Ring Closure: Single ADM interconnecting STM-16 and STM-1/4 rings

Two rings working at different or the same line speeds can be interconnected by a single Network Element as depicted in figure 3-9.

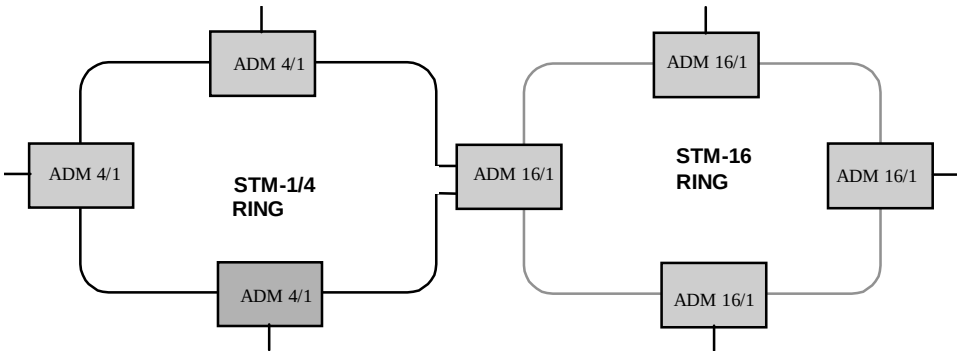


Figure 3-9. WaveStar® ADM 16/1 used as a Ring-closure network element

The WaveStar® ADM 16/1 system has the possibility to function as a ring closure network element because the architecture of the system makes it possible to have for instance 2 x STM-16 and 2 x STM-1 interfaces in one single shelf.

Dual Node Interworking

Two rings working at different or the same line speeds can be interconnected by two network elements, working in add/drop mode, protected by the Dual Node Interworking (DNI) protection mechanism as depicted in figure 3.10.

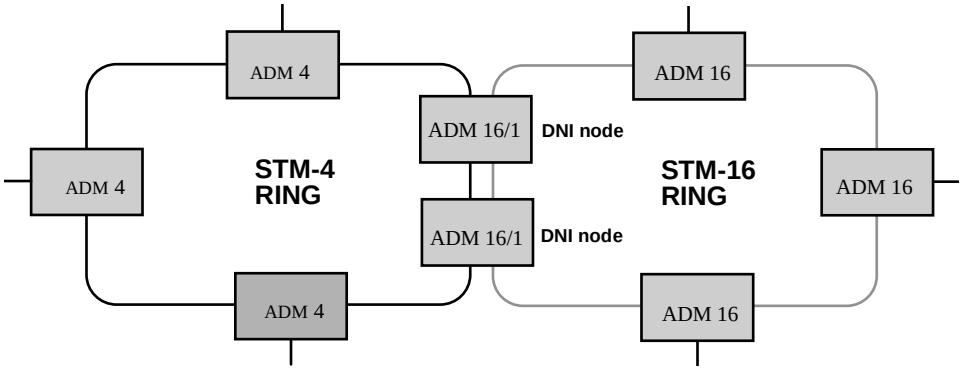


Figure 3-10. WaveStar® ADM 16/1 used as DNI network element

The DNI protection scheme protects the interconnection between two subnetworks within which the traffic is already protected by another network protection. This means traffic going from one node to another may be MS-SPRing or Path (SNCP) protected and will, in this case, be extra protected in the nodes interconnecting both rings by activating the DNI protection mechanism in these two nodes.

SONET-SDH Conversion and Interworking

The WaveStar® ADM 16/1 supports 2 different ways of interworking with SONET signals: interworking by AU-3 to TU-3 conversion and interworking on OC-3c and OC-12c level.

See also chapter 9, Mapping structure, for more details about the supported mapping features.

For SONET/SDH Interworking the WaveStar® ADM 16/1 supports the following feature:

- support of different size (ss)-bit on STM-1/4/16 interfaces (new standards):
  - In the source direction, the transmitted ss-bits can be provisioned in '10' (SDH mode, default) or '00' (SONET mode)
  - In the sink direction the incoming ss bits are ignored.

Interworking via AU-3 to TU-3 Conversion

In case of end-to-end DS-3 connection between SONET and SDH networks the AU-3 to TU-3 conversion can be used. The SONET networks maps the DS-3 into VC-3 and AU-3.

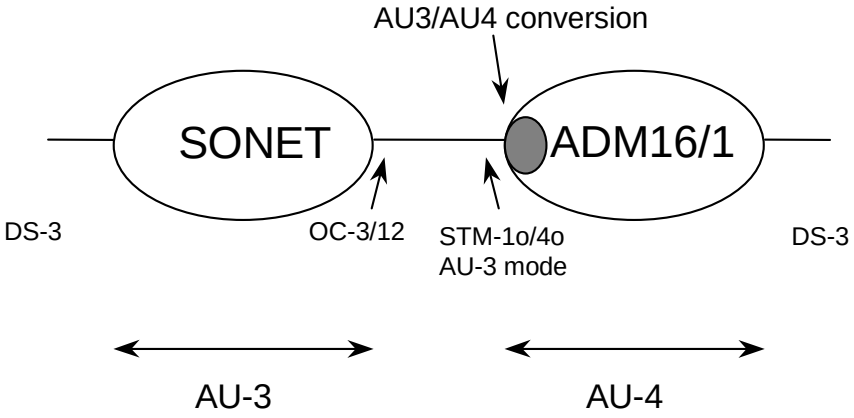


Figure 3-11. OC-3/OC-12 interworking with STM-1o/STM-4o via AU-3 to TU-3 conversion

The WaveStar® ADM 16/1 remaps the VC-3 into a TU-3/AU-4 structure (see figure below) and terminates the VC-3 on the DS-3 tributary interface units.

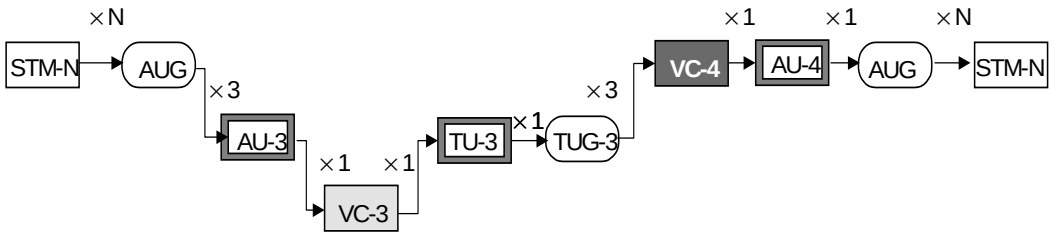


Figure 3-12. Remapping of VC-3 from AU-3 to TU-3/AU-4

Direct interworking between OC-3c and STM-1o and between OC-12c and STM-4o

Based on the equivalence between STS-3c and AU-4 pointers or between STS-12c and AU-4-4c pointers the WaveStar® ADM 16/1 is transparent for OC-3c and OC-12c signals. Pre-requisite is that the ADM16/1 operates in AU-4 (for STM-1o) or AU-4-4c (for STM-4) mode. This can be useful for inter-connecting ATM systems via mixed SONET and SDH networks.

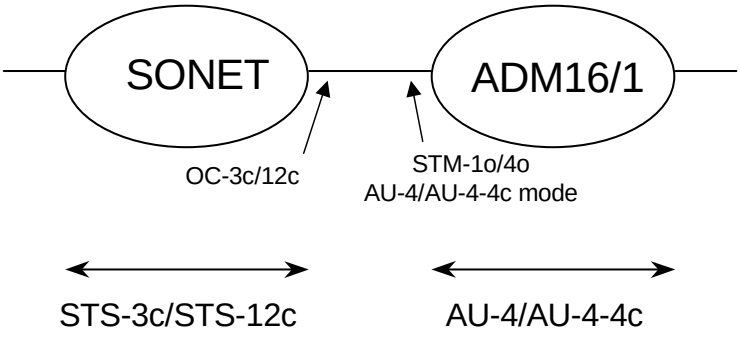


Figure 3-13. OC-3c/OC-12c interworking with STM-1o/STM-4o

Multi-service Application with Wavestar® TransLAN™ Card

The Ethernet LAN tributary card which is based on the Wavestar® TransLAN™ Card, enables the Wavestar® ADM 16/1 to provide Ethernet over SDH, and offers variable data applications on top of the traditional TDM applications. Therefore offers the customers cost-effective, simple and reliable multi-service solutions. TransLAN™ can provide VLAN function, and bandwidth can be shared for different customers.

Direct LAN-to-LAN Interconnect (more than two LAN's)

The most straight-forward application of the Ethernet LAN tributary card is to interconnect two LAN segments that are at a distance where can not be reached with a simple Ethernet repeater, since that would violate the collision domain size rules. Both LAN's need not be of the same speed. It is possible to interconnect a 10Base-T and a 100Base-TX LAN this way. This application is shown at Figure 3-14.

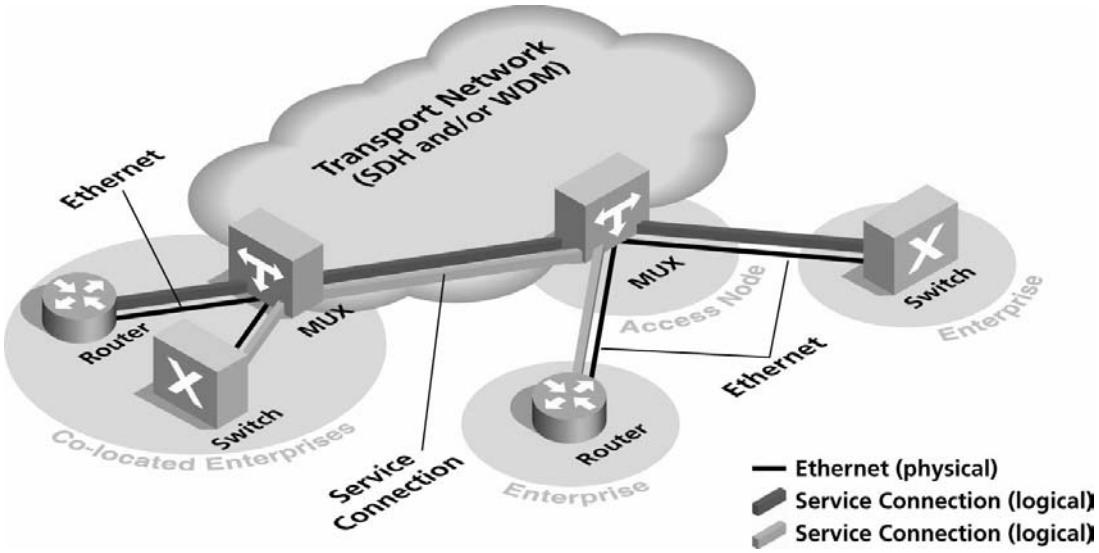


Figure 3-14. Example of direct LAN-LAN interconections

Direct Direct LAN-to-LAN Interconnect (more than two LAN's)

A next step in complexity is to interconnect multiple LAN's at different locations. It is possible to associate a single LAN port with two or more WAN ports. This way multiple sites can be interconnected, forming a fully L2 switched WAN Ethernet network. This application is shown at Figure 3-15.

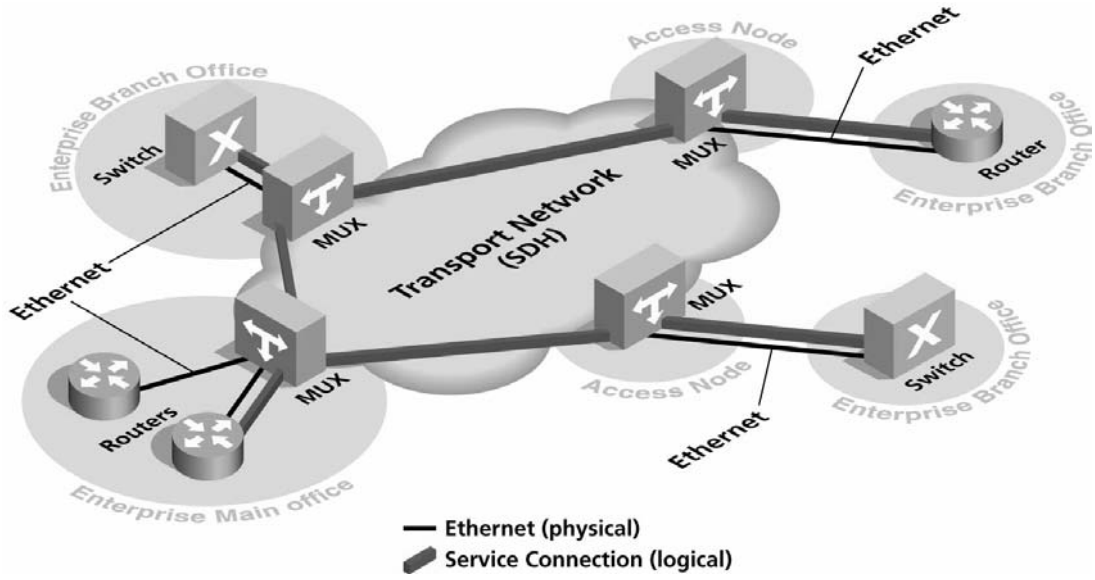


Figure 3-15. Example of direct LAN-LAN interconections

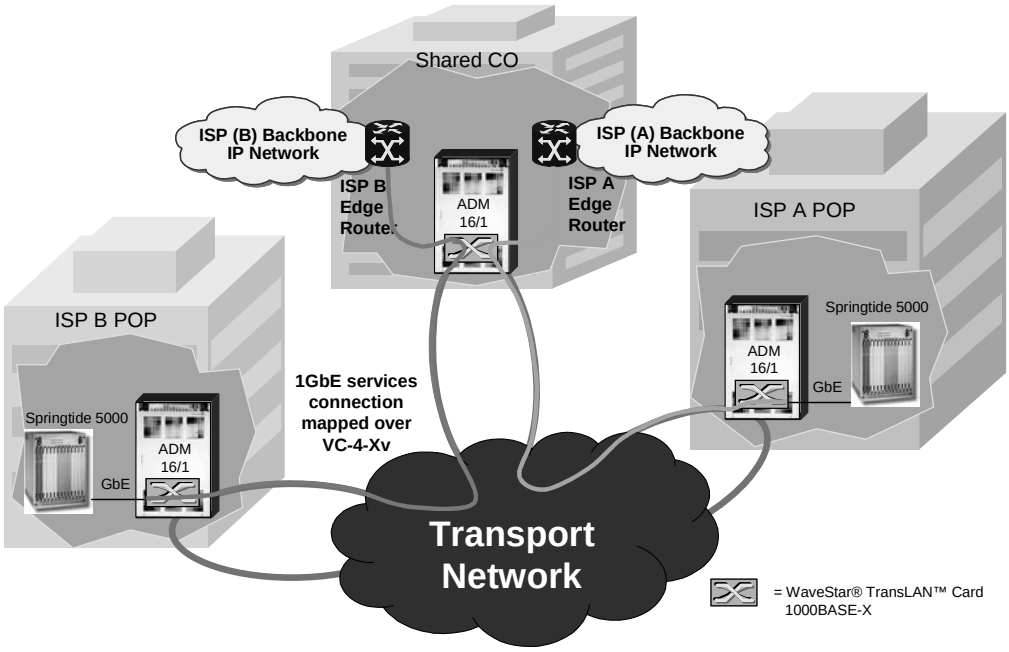


Figure 3-16. GbE Point Multi-Point Services Example.

LAN-ISP Interconnect

An extension of the previous application is to have one LAN drop of a multi-point LAN-to-LAN interconnection at the point of presence of an ISP, to provide for instance internet access to the users in the company LANs. This application is shown at Figure 3-16.

Multiple Customers sharing a WAN Connection

To increase the efficiency of the bandwidth usage, it is possible to route the Ethernet traffic of multiple end-users over the same SDH facilities. This feature is called LAN-VPN and makes use of customer VPN tags, a tagging scheme derived from IEEE802.1Q VLAN standard to separate the traffic of the different users. This application is shown at Figure 3-17.

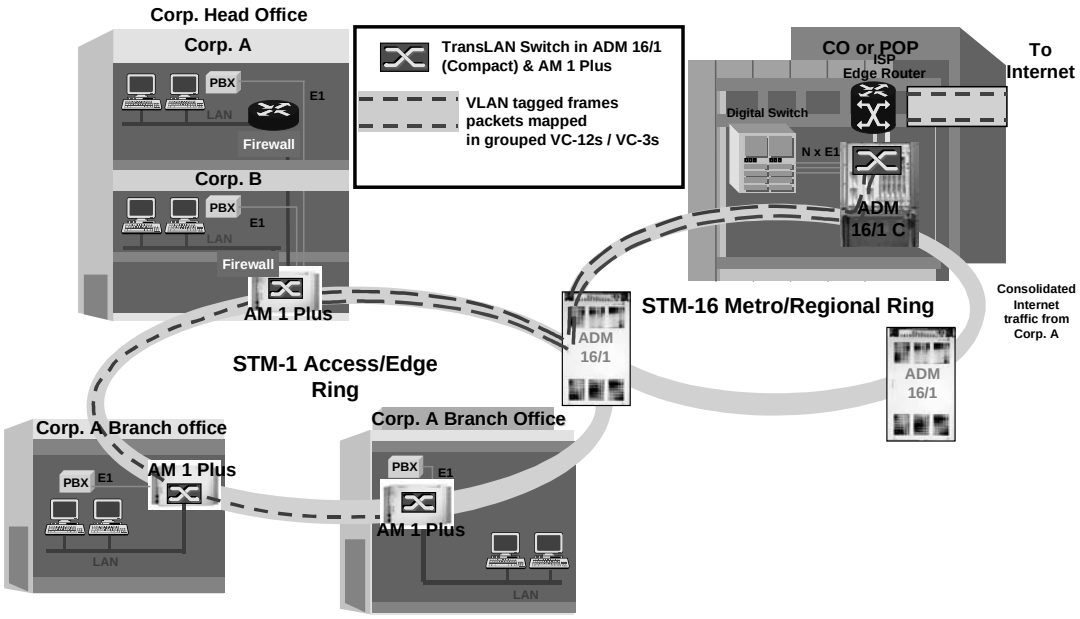


Figure 3-17. Example of a LAN-VPN application

VLAN Trunking

At the ISP premises, the aggregated LAN traffic from multiple customers (i.e. multiple VLANs) via one single high capacity Ethernet link (Fast Ethernet or Gigabit Ethernet) to data equipment in a Central Office or ISP POP such as an IP edge Router, IP Service Switch or ATM Switch, can be handled by means of the VLAN trunking feature. VLAN trunking is a possible application of the new 802.1Q VLAN Tagging scheme supported in the Pearl release. Main benefit of the VLAN trunk feature is that Wavestar® TransLAN™ cards can hand off end user LAN traffic via one high capacity LAN port instead of multiple low speed LAN ports, thus reducing port, space and cabling costs. In Figures 3-18/3-19/3-20 examples are given of different of VLAN Trunking applications.

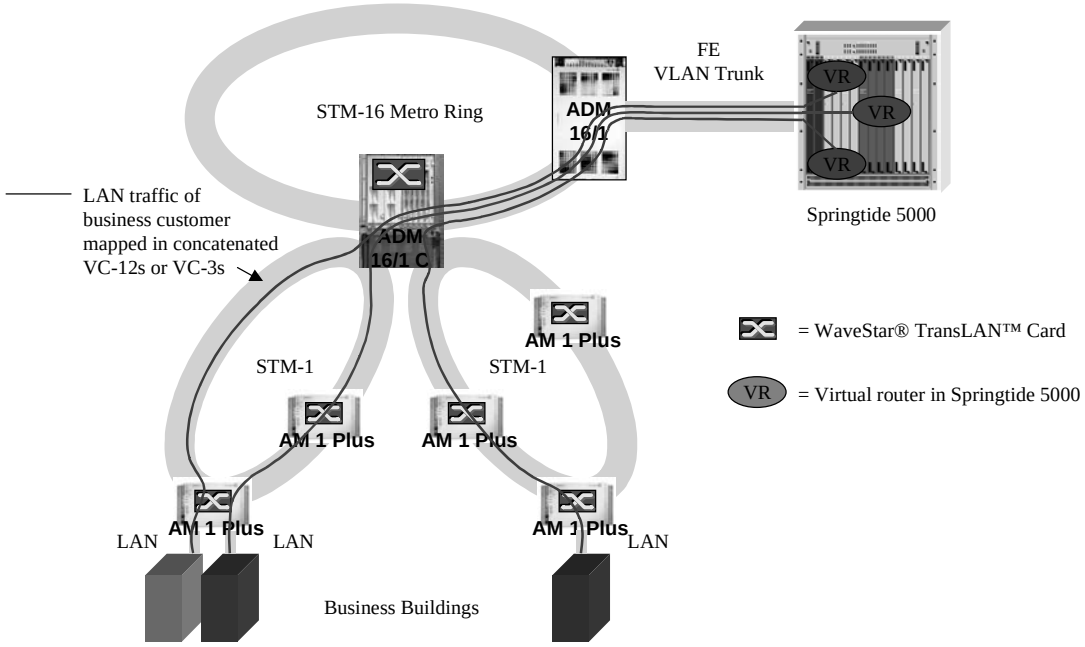


Figure 3-18. VLAN Trunking Example.

Figure 3-19. FE to GE Trunking Example

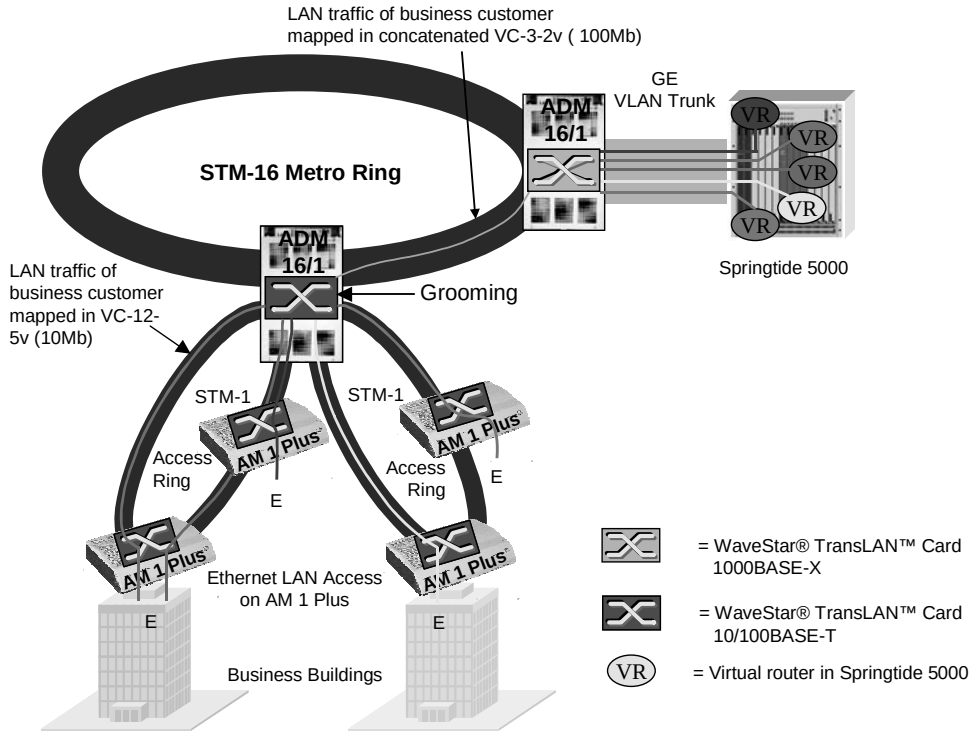


Figure 3-20. Ethernet to GE Trunking Example

DCN support with Ethernet LAN tributary unit

The Ethernet LAN tributary unit can also be used for DCN engineering purposes. An important application in this respect is to use the Ethernet interfaces to make a long distance Q-LAN connection. This solution can replace the current solution that uses external modems or routers. It is often cheaper and easier to manage if the long distance Q-LAN connection can be made over the SDH infrastructure (at the cost of the bandwidth of a few VC12s).

The DCN application of the Ethernet LAN tributary card assumes the Wavestar® ITM-SC co-located with at least one of the NEs equipped with this tributary card (e.g., Wavestar® AM1 Plus, Wavestar®ADM 16/1 Compact or Wavestar® ADM 16/1). In such case, one can connect the Ethernet port of the Wavestar® ITM-SC to one of the designated 10Base-T/100Base-TX LAN port and configure the associated WAN port with desired bandwidth (e.g., VC12) to carry the management traffic.

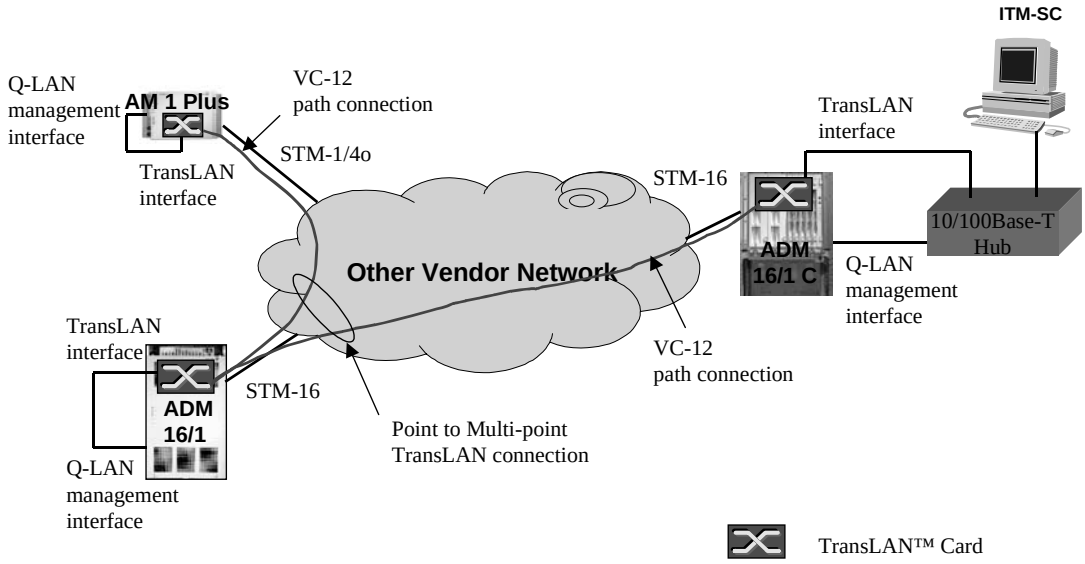


Figure 3-21. DCN support with Ethernet LAN tributary unit

Description

4

Overview

This chapter provides a more detailed view of the system composition and the shelf complements of the WaveStar® ADM 16/1 Multiplexer and Transport System. The system functions and circuit packs are described following the description of the system architecture, the partitioning of the circuit packs in the system, and the physical design. Additional information is provided relating to protection and timing architecture.

Introduction

This chapter describes the WaveStar® ADM 16/1 in terms of basic architecture, physical configuration and circuit packs.

In addition, equipment redundancy and protection are briefly summarized.

Basic WaveStar® ADM 16/1 Architecture

This very flexible product resulted from a great step forward in technology. Owing to the high level of integration at circuit-pack level, it is possible to Add/Drop up to 504 x 1.5 Mbit/s, 504 x 2 Mbit/s, 48 x 34 Mbit/s, 96 x 45 Mbit/s, 64x10/100 Base-T Ethernet,16x GbE interfaces (Gigabit Ethernet), 96 x STM-0, 32 x 140 Mbit/s, 32 x STM-1 or 8 x STM-4 using only one subrack.

The WaveStar® ADM 16/1 is a multiplexer and transport system that multiplexes a broad range of plesiochronous and synchronous signals into 2.5 Gbit/s (STM-16), 622 Mbit/s (STM-4) or 155 Mbit/s (STM-1). The method used to map the interface signals complies with the ITU-T specified AU-4 mapping procedure. STM-1 and STM-4 optical tributary interfaces also support AU-3 mapped signals.

The system can be used as an add/drop multiplexer, terminal multiplexer or small local cross-connect. It provides built-in cross-connect facilities and flexible Interface circuit packs. Local and remote management and control facilities are provided via the Q and F interface and the embedded communication channels. The cross-connect circuit pack is the core of the WaveStar® ADM 16/1 system.

An outline of the basic WaveStar® ADM 16/1 architecture is given in figure 4-1.

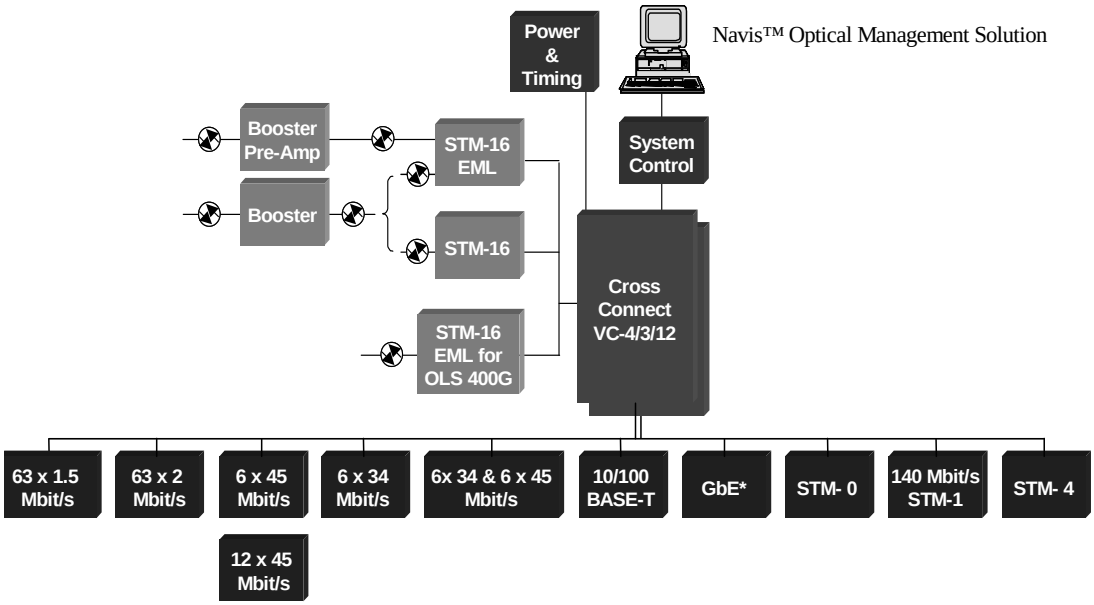


Figure 4-1. Basic architecture of the WaveStar® ADM 16/1 system

The cross-connect

The cross-connect is the core of the WaveStar® ADM 16/1 system. The cross-connect circuit pack functionally consists of two parts: a higher and a lower order cross-connect, although physically the cross-connect circuit pack is a single circuit pack.

The higher order cross-connect switches VC-4s and its capacity is 64 x 64. Other functions of the higher order cross-connect are: VC-4 SNC protection switching, MS-SPRing protection, MSP, equipment protection of tributary slots (see at the end of this Chapter and at Chapter 2 for detailed explanations of mentioned protection mechanisms), non-intrusive monitoring of VC-4s and broadcasting.

The lower order cross-connect switches/grooms VC-3 and VC-12s and its capacity ranges up to 2016 x 2016 VC-12s equivalents or 32 x 32 VC-4s. Other functions of the lower order cross-connect are: lower order SNCP protection, non-intrusive monitoring of lower order VCs and lower order broadcasting.

Tributary and line interfaces circuit packs are directly connected to the higher order cross-connect via STM-1 equivalent signals.

Higher- and lower order cross-connect parts are interconnected via an internal cross-connect-bus of 32 bi-directional VC-4s wide. The lower order cross-connect itself is uni-directional although traffic can be switched/protected bi-directionally (= default situation).

Higher order VC-4s arriving from line or tributary circuit packs need only to be routed through the lower order matrix, if the lower order VC content needs to be groomed. Otherwise, the VC-4 can be routed through the higher order cross-connect only.

Flexible routing and cross-connecting of VC-4, VC-3 and VC-12 between line port ⇔ line port, line port ⇔ tributary port and tributary port ⇔ tributary port is possible.

The system architecture makes it possible to use an interface circuit pack in almost any other slot position, hence the system becomes very flexible. A broad range of applications can be served with the same shelf based on a common software platform.

To contribute to overall system reliability and availability, the cross-connect circuit pack can be 1 + 1 equipment protected by an accompanying circuit pack.

Fixed cross-connect

The fixed connection unit replaces the (working) cross-connect unit to provide a 0:1 or 0:2 terminal configuration, in which the (16) VC-4s of four tributary units are routed towards one line port unit and the (16) VC-4s of four other tributaries are routed towards the other line port unit. The protection cross-connect slot remains unassigned, as well as one of the tributary slots. The tributary units can be all types, but it is understood that if a PI-E1/63 is used, then 3 VC-4's worth of line capacity become unreachable for each inserted PI-E1/63 unit.

No equipment protection of tributary cards is supported, nor of line cards or cross-connect units. Only the PT unit can be protected. Network protection schemes like MSP, MS-SPRing or SNCP are not supported either.

Interface circuit packs

The WaveStar® ADM 16/1 supports a large variety of interface circuit packs: 1.5, 2, 34, 45, 140 Mbit/s, 10/100 Base-T Ethernet, GbE (Gigabit Ethernet), STM-0, STM-1, STM-4 and STM-16 are the circuit packs that can be used. If required, interface redundancy can be provided. For details of these circuit packs please refer to ‘circuit packs’ described later in this chapter.

System control and management

The System controller (SC) controls and provisions all circuit packs via a local LAN bus. The SC also provides the external operations interfaces for office alarms, miscellaneous discretes and connections to the overhead channels (a maximum of six overhead bytes may be selected to be connected to six connector on the interconnection box).

The SC also facilitates first line maintenance by several LEDs and buttons on the front panel. General status and alarm information is displayed. Various controls and an F-interface connector, for a local maintenance PC (ITM-CIT), are also located on this panel.

The SC communicates with the centralized management system (WaveStar® ITM-SC and Navis™ Optical NMS).

A part of the SC, routing management information between SDH equipment and the element management system, is called data packet switch (DPS). Communication is established via so-called data communication channels (DCC) (= D1-3/D4-12 bytes), within the STM-N section overhead signals or via one of the Q-interfaces of the system. Information destined for the local system is routed to the System Controller, while other information is routed from the node via the appropriate embedded channels of the STM-N line or tributary signals.

The WaveStar® ITM-SC manages the WaveStar® ADM 16/1 at the element level and the Navis™ Optical NMS manages the system at the network level. The ITM-Craft Interface Terminal (ITM-CIT) can be used for managing small networks and for maintenance.

Power and Timing

In addition to the transmission and control functions briefly described above, the WaveStar® ADM 16/1 can be equipped with one or two power and timing circuit packs (PT).

Power

A basic function of the PT circuit pack is to filter and stabilize the incoming station power in order to meet the necessary ETSI requirements. The basic power distribution

philosophy throughout the WaveStar® ADM 16/1 is to equip each circuit pack with on-board DC/DC converters that convert the customer's secondary (station battery) voltage to the voltages required for each circuit pack. The power feed from the station battery voltage is maintained duplicated throughout the system’s backplane.

Timing

Another basic function of the PT is system timing. The local oscillator, also called the SDH equipment clock (SEC), can be synchronized to one of the user-selectable timing references. There are two types of PT circuit packs available: one so-called standard PT with a standard hold-over stability of 2048 kHz ± 4.6 ppm and one with a more accurate hold-over stability frequency of 2048 kHz ± 0.37 ppm (Stratum-3).

Shelf Complements

The WaveStar® ADM 16/1 is a single-row subrack designed for application in 600-mm deep ETSI rack frames.

The shelf of the D700 type construction provides the facilities to house the WaveStar® ADM 16/1 circuit packs. It consists of the mechanics, a backplane and an integrated interconnection box (ICB). Via the interconnection box access to overhead channels, station alarms, miscellaneous discretes and Q-LAN is possible.

Cabling to the customer is pre-fabricated and will be connected to the rear of the subrack. If protection or impedance conversion is needed, special paddle boards can be inserted between customer cabling and the backplane. Optical interfaces are located on the front (STM-4 and STM-16 signals) and rear (STM-0 and STM-1 signals) of the system.

The subrack is called the high-density subrack. An integrated fan unit cools the system circuit packs. This fan unit is part of the WaveStar® ADM 16/1 subrack.

The High-density shelf is provided with (figure 4-2):

- 1 slot for the System controller (SC) which includes DPS functionality
- 2 slots for the line circuit packs (SI-16)
- 2 slots for the cross-connect circuit packs (CC)
- 9 slots for the tributary circuit packs
- 2 slots for the power and timing circuit packs (PT).

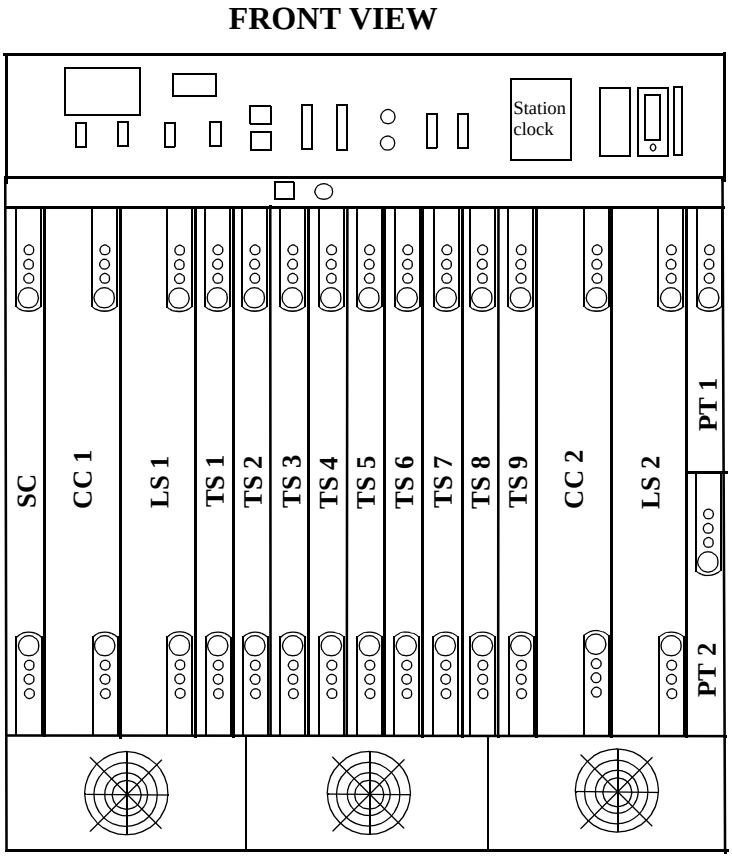


Figure 4-2. WaveStar® ADM 16/1 High density shelf (EFA4) configuration

Electrical Paddle boards

A variety of paddle boards exists for connection between customer cabling and the backplane in case of protection or impedance conversion. All paddle boards can be inserted from the rear of the equipment and fit on the 2 mm-Pitch backplane connectors.

The paddle boards contain the hardware to adjust the impedance or to provide equipment protection.

Paddle boards:

- for 1.5 Mbit/s:

Name:	Function:
PB-DS1/100/32	75 to 100 Ω impedance conversion board, 32 channels
PB-DS1/P100/32	75 to 100 Ω impedance conversion + protection board, 32 channels

Two identical 1.5 Mbit/s paddle boards are mounted behind a worker circuit pack to provide impedance adaption.

- for 2 Mbit/s:

Name:	Function:
PB-E1/75/32	Direct through connections paddle board, 32 channels, 75 Ω
PB-E1/P75/32	Protection paddle board, 32 channels, 75 Ω
PB-E1/120/32	75 to 120 Ω impedance conversion paddle board, 32 channels
PB-E1/P120/32	75 to 120 Ω impedance conversion + protection paddle board, 32 channels

All 2 Mbit/s paddle boards are mounted behind the worker circuit packs. No paddle board is needed behind the protecting 2 Mbit/s circuit pack.

- for 34/45 Mbit/s:

Name:	Function;
PB-E3DS3/6	Protection paddle board, 6 channels

The PB-E3DS3/6 is mounted horizontally across the worker and the protecting circuit pack.

- for STM-1e / 140 Mbit/s:

  Name: Function:

  PB-1E4/PW/2 Protection paddle board to be used in combination with ‘worker’ circuit packs, 2 channels

  PB-1E4/PP/2 Protection paddle board to be used in combination with ‘protection’ circuit pack, 2 channels

- for 10/100 Base-T Ethernet

  Name: Function:

  PB-LAN/4 Paddle board with 4 interfaces without protection to be used in combination with IP-LAN/8 circuit packs.

NOTE:
For more details on equipment protection, see Chapter 8, System Planning and Engineering

Circuit packs

Figure 4-1 shows the circuit packs that can be used with the WaveStar®ADM 16/1 system.The Interface circuit packs are briefly described here. For an explanation of the naming of the circuit packs, please refer to Chapter 8.

Optical interface circuit packs

The WaveStar® ADM 16/1 can be equipped with STM-16, STM-4, STM-1 and STM-0 optical interface circuit packs, which are available in several types. Options for STM-16 are 1310 nm (Long-haul), 1550 nm (Long-haul), the STM-4 (1310 nm Short-haul and 1550 nm Long-haul), STM-1 and STM-0 optical units are using the 1310 nm Short-Haul version.

All STM-4 and STM-16 optical packs are equipped with a universal built-out optical connector type, allowing the connector type to FC/PC or SC to be changed on-site depending on the customer needs.

The STM-1 optical circuit packs do have a SC-connection with a conversion possibility to FC/PC.

The STM-0 does have a LC-connection with a conversion possibility to FC/PC or SC.

The WaveStar® ADM16/1 can also be equipped with GbE Pluggable optical option cards up to a maximum of 8.

For optical interfaces located on main plug-in units, the access is through the front of the system, directly to the connector on the front of the unit in question. For optical interface located on paddle boards, the access is via the rear of the system, directly on the optical connector on the paddle board in question.

STM-16 optical line port units

All power budgets indicated below are ‘end-of-life’.

- SI-L 16.1/1C and SI-L 16.1/1D (1310 nm ITU, ITU-T G.957)
  - 10-24 dB over G.652 fiber at a BER of $1x10^{-10}$ (L-16.1)

    Including 2 dB margin for temperature and aging and 1 dB optical path penalty.
  - 10-23 dB over G.652 fiber at a BER of $1x10^{-12}$ (L-16.1)

    Including 2 dB margin for temperature and aging and 1 dB optical path penalty.
- SI-L 16.2/1C and SI-L 16.2/1D (1550 nm ITU, ITU-T G.957)
  - 11-24 dB over G.652 fiber at a BER of $1x10^{-10}$ (L-16.2)

Including 2 dB margin for temperature and aging and 2 dB optical path penalty (i.e. up to 1800 ps/nm dispersion).

- 11-25 dB over G.653 fiber at a BER of $1x10^{-10}$ (L-16.3)

  Including 2 dB margin for temperature and aging and 1 dB optical path penalty.

A special circuit pack has been developed to bridge ultra-long distances (up to 160 km) that amplifies the transmitted and received signals. This circuit pack can be placed in any slot position normally used for a tributary circuit pack.

Booster pre-amplifier:

- LBPA-U 16.2/1
  - This circuit pack has to be mounted in front of a transmitter, in one of the tributary slots.
- SI-EML U16.2/1 (1550 nm, ITU-T draft rec. G.691)
  - 33-44 dB over G.652 fiber at a BER of $1x10^{-12}$ (U-16.2)

    Including 2 dB margin for temperature and aging and 2 dB optical path penalty.
  - 33-45 dB over G.653 fiber at a BER of $1x10^{-12}$ (U-16.3)

    Including 2 dB margin for temperature and aging and 1 dB optical path penalty.

Booster:

- LBA-V16.2/1 (1550 nm, ITU-T G.691 V-16.2/3)
  - This circuit pack has to be mounted in front of a transmitter, in one of the tributary slots.

Eighty different Wavelengths, with compatible optics (STM-16) are available for interworking with the WaveStar® OLS 1.6T:

- SI-16EMLx/1 (x ranging from 9190 to 9585 (1530-1565 nm)). x represents the frequencies, which range from 191.90 THz to 195.85 THz in steps of 50 GHz

Two simple WDM coupler units (Gould KIT ASSY MODULE WDM KIT, comcode 848270682) can be mounted in the system to allow single fiber operations:

- Co-directional 2 wavelength WDM operation:

  It is possible to combine the optical signals from the line interfaces of the ADM 16/1 systems, when one system operates in the 1310 nm region and the other in the 1550 nm region, so that the optical signals travel in the same direction. The net

power budget for this type of operation on standard fiber, after subtracting the coupler and extra connector losses is 20 dB at 1x 10^{-10} BER.

- Contra-directional 2 wavelength WDM operation:

  It is possible to combine the optical transmit and receive signals from the line interface of one WaveStar® ADM 16/1 system, when one direction operates in the 1310 nm region and the other in the 1550 nm region, so that the optical signals travel opposite directions of each fiber. The net power budget for this type of operation on standard fiber, after subtracting the coupler and extra connector losses is 20 dB at 1x 10^{-10} BER.

Optical interfaces for tributaries (STM-0 and STM-1)

The optical interface circuit packs listed below must always be used together with a tributary circuit pack (SA-0/12, SIA-1/4B or SPIA-1E4/4B) described later in this chapter. They must be mounted behind the tributary circuit pack (just like a paddle board). See also Chapter 8. These circuit packs provide the optical circuits and are provided with an optical connector. Via a patch panel with a fiber management system this connector can be converted to a SC or FC/PC connector.

An optical interface paddleboard contains 2 x STM-1 or 6 x STM-0 Interfaces, to be used together with the tributary circuit packs:

- OI-S 1.1/2 (1310 nm, ITU-T G.957)
  - 0-12 dB at a BER of 1x10^{-10} (S-1.1) (STM-1)
- OI-L1.2 (1550 nm):
  - 10-28 dB at a BER of 1 x 10^{-10} (L-1.2).
- OI- 0/6 (1310 nm):
  - 0-10 dB at a BER of 1x10^{-10} (STM-0)

Optical tributaries (STM-4)

There is also an optical interface for a STM-4 signal on a tributary port. This circuit pack has front access and does not use optical interfaces at the backside.

- SI-S 4.1/1 (1310 nm, ITU-T G.957)
  - 0-12 dB (1 x 10^{-10} sensitivity) at an operating wavelength of 1310 nm.
- SI-L 4.2/1 (1550 nm, ITU-T G.957)
  - 10-24 dB (1 x 10^{-10} sensitivity) at an operating wavelength of 1550 nm

Optical tributaries (1000BASE-X)

The WaveStar® ADM16/1 can also be equipped with 1000BASE-X tributary units. The circuit pack provides two interfaces for which the follwing pluggable optics are available:

— 1000BASE- SX (850 nm short haul, multi-mode)

— 1000BASE-LX (1310 nm long haul, multi-mode or single-mode)

The optical interfaces are present at the front-side of the system via LC connectors.

Electrical tributaries circuit packs

The electrical tributaries circuit packs contain the Low-speed interfaces. The interface circuit packs provide the plesiochronous interface circuits or synchronous STM-1 interfaces and alignment into TUs.

The following Electrical Interface circuit packs can be provided:

- PI-DS3/63: 63x1.5 Mbit/s interfaces per circuit pack
- PI-E1/63: 63x2 Mbit/s interfaces per circuit pack
- PI-E3/6: 6x34 Mbit/s interfaces per circuit pack
- PI-DS3/6: 6x45 Mbit/s interfaces per circuit pack
- PI-DS3/12: 12x45 Mbit/s interfaces per circuit pack
- SPIA-1E4/4B: 4xSTM-1e/140 Mbit/s interfaces per circuit pack
- SIA-1/4B: 4xSTM-1e interfaces per circuit pack
- IP-LAN/8: 8x10/100 Mbit/s Base-T interfaces per circuit pack (Ethernet stream is mapped into 1 to 4 VC-12s),
- IP-LAN 8 Tlan: 8x10/100 Mbit/s Base-T interfaces per circuit pack (Mapping of Ethernet traffic into VC-12-xv and VC-3-xv).

Ethernet LAN tributary board, IP-LAN 8 Tlan, (LJB459)

On the WaveStar® ADM 16/1 an Ethernet LAN tributary board (a.k.a. IP-LAN 8 Tlan) is available providing eight 10/100Base-T Ethernet interfaces. This tributary board is based on the WaveStar® TransLAN™ Card. When equipped with WaveStar® TransLAN™ Card, Lucent Technologies SDH multiplexers can offer besides TDM services like DS1, E1, E3/DS3, E4, STM-1, STM-4 and STM-16 interfaces also 10/100Base-T Ethernet interfaces. Below a description is given of the Ethernet LAN tributary board functionality supported by the WaveStar® ADM 16/1.

An Ethernet LAN tributary board, based on the WaveStar® TransLAN™ Card, is also available for the WaveStar® AM 1 Plus and WaveStar® ADM 16/1 Compact. Please refer to the applicable Application and Planning Guide (APG).

Speed, Cable, Connector

The LAN interfaces that are supported are 10Base-T and 100Base-TX. The numbers "10" and "100" indicate the bit-rate of the LAN, 10 Mbit/s and 100 Mbit/s respectively. The "T" or "TX" indicates the wiring and connector type: Twisted pair wiring with RJ-45 connectors.

The actual LAN speed does not need to be configured, since the Ethernet interfaces support the auto-negotiation protocol, which enables them to select automatically the proper LAN speed.

The Auto-negotiation function on the Ethernet LAN tributary board is configurable. This feature allows the auto-negotiation function to be manually overriden from WaveStar® ITM-SC or the ITM-CIT. If this auto-negotiation function is disabled, it is possible to select a specific operational mode (10 or 100Base-T, Half/Full-Duplex).

CSMA/CD principles

The Ethernet type that is supported by the Ethernet LAN tributary board is according to IEEE 802.3 Ethernet, which means that the access control to the LAN is according to the CSMA/CD principles: Carrier Sense Multiple Access with Collision Detection. "Multiple Access" means that all hosts on the LAN may transmit packets whenever they need to, provided nobody else is transmitting at the same time: "Carrier Sense". In case there is simultaneous transmission of two or more hosts, the "Collision Detect" part of the protocol prescribes how this situation needs to be detected and resolved. The larger the size of a LAN, the higher the probability of collisions, due to the finite propagation times of the frames over the LAN. For this reason, there are rules about minimum frame lengths and maximum LAN sizes. LAN’s can only be made larger by splitting them in multiple "collision domains". Within each collision domain, the normal CSMA/CD rules apply.

Traffic between collision domains needs to be transported via a special device known as a bridge. The bridge can store frames from one collision domain and forward it in another collision domain once the LAN is free. A WaveStar® ADM 16/1 equipped with Ethernet LAN tributary boards contain this bridge functionality, which allows to have virtually unlimited distances between the LAN's that need to be interconnected.

To end-users, the "TransLAN Network" (a network build with WaveStar® AM 1 Plus, WaveStar® ADM 16/1 Compact and WaveStar® ADM 16/1 equipped with Ethernet LAN tributary boards), appears as a single bridge interconnecting their CPE LAN’s. Thus, end-users do not have to consider the "TransLAN Network" in the design rules (e.g., number of repeaters, distance, collision domain size) of their end-to-end Ethernet network. Collision domains interconnected via "TransLAN Network" will always be fully separated.

This is in contrast to the situation where the WaveStar® ADM 16/1 is used as a repeater. A repeater just forwards all frames it receives, without considering the destination MAC address. A repeater does not separate collision domains so the two parts on each side of the repeater should be considered as one Ethernet network.

The implementation of the Ethernet LAN tributary board supports star topologies. The maximum LAN segment of CPE LAN's connected to the Ethernet LAN tributary board should be compliant to the Ethernet LAN design rules defined in IEEE802.3. As a reference, the maximum distance from an end device (e.g., PC, host) to an Ethernet LAN tributary board should be less than 100 meters.

Ethernet Communication Mode, Speed Negotiation

Data devices connected through a single collision domain of a Fast Ethernet LAN usually communicate in half-duplex mode, a communication method in which a device may either send or receive data at a given instance, but not both.

The newer design of Ethernet switches and hubs today supports both half-duplex and full-duplex mode of communication. Full-duplex mode is a communication method that allows a device connected to the switch or hub to simultaneously send and receive data. To support communication in full-duplex mode, it requires the use of full-duplex media, the cable/wire that provides independent transmit and receive data paths. Note: an Ethernet LAN with full-duplex media does not mean it operates in full-duplex mode.

Before sending and receiving data between two devices connected through an Ethernet LAN, they must both agree to the communication speed (e.g., 10 Mbit/s or 100 Mbit/s), communication mode (half-duplex or full-duplex) and support of flow control capability. The auto-negotiation protocol defined in the Ethernet standard specifies a process to reach such agreement between the devices during the device initialization phase. The process uses special signals to carry the auto-negotiation information between the devices. We support the auto-negotiation protocol and by default, the auto-negotiation function is always on.

In some field cases, it is known that auto-negotiation can fail. In order to allow interworking with equipment not supporting this function, the WaveStar® ADM 16/1 supports an option to override the auto-negotiation. The user has the possibility to disable the auto-negotiation and to force the port speed (10 or 100 Mbit/s) and the half or full-duplex mode.

WAN Bandwidth

To facilitate the flexibility of mapping mixed higher layer traffic into SDH/SONET circuits, and to offer better granularity, ITU G.707 and G.783 (2000 edition) have recently standardized virtual concatenation, a byte-level inverse-multiplexing technique. The virtual concatenation allows the mapping of different types of traffic (e.g., Ethernet, TDM) to individual SDH channels (VCs) that are associated in a concatenated group. The key difference between contiguous concatenation and virtual concatenation is the

transport between the path termination. Contiguous concatenation maintains the contiguous bandwidth through out the whole transport, while virtual concatenation breaks the contiguous bandwidth into individual VCs, transports the individual VCs and recombines these VCs to a contiguous bandwidth at the end point of the transmission. Virtual concatenation requires concatenation functionality only at the path termination equipment, while contiguous concatenation requires concatenation functionality at each network element. Thus virtual concatenation is perfectly suited for interworking with legacy nodes in a multi-vendor SDH environment, where traffic can be transparently transported over the legacy nodes not supporting the feature.

WAN bandwidth is supported and defined based on the amount of VCs being allocated (provisioned and configured) for it. The Ethernet LAN tributary board supports WAN bandwidth of mixed VC types. The only limitation is fixed by the maximum capacity between the Ethernet LAN tributary board and the backplane of the WaveStar® ADM 16/1, i.e. two VC-4.

Ethernet WAN Port Capacity Configuration Rules

The encapsulated Ethernet frames are mapped in VC-12 (2 Mbit/s), VC-12-2v (4 Mbit/s), VC12-3v (6 Mbit/s), VC12-4v (8 Mbit/s), VC12-5v (10 Mbit/s), VC3 (50 Mbit/s) or VC3-2v (100 Mbit/s). A user can provision the actual per WAN port bandwidth. Since the backplane capacity is limited, the total combined bandwidth of all WAN ports together must follow the WAN capacity configuration rules defined in Table 4-1.

Notice that only the WAN port bandwidth dictates the effective end-to-end Ethernet communication throughput, not the LAN ports.

Table 4-1. WAN Port Capacity Configuration Rule

WAN Capacity Configuration Case	Capacity of WAN Port 1	Capacity of WAN Port 2	Capacity of WAN Port 3	Capacity of WAN Port 4	Note
1	VC-3-2v	VC-12-xv	VC-12-xv	VC-12-xv	x = 0, 1,..,5
2	VC-3	VC-3	VC-12-xv	VC-12-xv	x = 0, 1,..,5
3	VC-3	VC-12-xv	VC-12-xv	VC-12-xv	x = 0, 1,..,5
4	VC-12-xv	VC-3	VC-12-xv	VC-12-xv	x = 0, 1,..,5
5	VC-12-xv	VC-12-xv	VC-12-xv	VC-12-xv	x = 0, 1,..,5

One Ethernet LAN tributary board supports 8 ports divided over 2 groups. The first WAN port group (Port 1 to 4) supports the possible combination of Ethernet WAN port (total of 4) capacity configurations defined in Table 4-1.

The second WAN port group (port 5 to 8) of the WaveStar® ADM 16/1 supports the same capacity configurations as defined for the first WAN port group (port 1 to 4).

The Ethernet LAN tributary board equipped WaveStar® ADM 16/1 system keeps track of the available capacity according to the rules defined in the WAN port configuration table above. If an attempt to configure a new WAN port capacity violates the rules, not only the system will not grant the new configuration but also an alarm (message) will be triggered and displayed.

TransLAN Operation Modes

The physical L2 switch that is present on an Ethernet LAN tributary board can be split into several logical or virtual switches. A Virtual Switch is a set of LAN/WAN ports on a Ethernet LAN tributary board that are used by different VLAN's which can share the common WAN bandwidth. Each of the virtual switches can operate in a specific Virtual Switch mode depending on the VLAN tagging scheme, and each Virtual Switch mode allows specific LAN-WAN port associations as explained in the following paragraphs.

First the VLAN tagging mode has to be specified on LAN unit level, this can be either IEEE 802.1Q VLAN tagging or VPN-tagging. In VPN tagging mode, end-user VLAN tags that optionally may appear in the end user traffic are ignored in the forwarding process. These VLAN tags are carried transparently through the "TransLAN Network". In VLAN-tagging mode, the VLAN tags are also carried transparently, but the VLAN ID in the VLAN tags is used in the forwarding decision. Therefore customers' VLAN IDs may not overlap on a physical Ethernet switch, the VLAN IDs must be unique per physical switch.

After having provisioned the tagging mode, per virtual switch a different Virtual Switch operational mode may be chosen. In the Pearl release, the Ethernet LAN tributary board supports either the Repeater mode, LAN-Interconnect, LAN-VPN, and Spanning Tree Protocol Virtual Switch mode of operation. IEEE 802.1D MAC forwarding and address filtering, multi-point bridging and spanning tree protocol (STP) are supported under all modes of operation, except the Repeater mode. In Table 4-2 an overview of the different modes and a list of the corresponding supported functionality is given.

Table 4-2. Overview of the Virtual Switch Modes

VLAN Tagging Scheme	Virtual Switch Mode	Dynamic VLAN/ VPN Registration Protocol	Spanning Tree Implementation	Root Bridge Selection
IEEE 802.1Q VLAN Tagging	STP Switch	GVRP, None	Single STP per Virtual Switch	Provisionable
VPN Tagging	Repeater	N/A	No STP	N/A
	LAN Interconnect (Dedicated Bandwidth)	STVRP (Automatic via BPDU's)	STP per VPN	Smart values per VPN
	LAN-VPN (Shared Bandwidth)		STP per VPN	

Repeater mode

The Repeater mode is expected to be the most widely used application with the Ethernet LAN tributary board. In this case there is a point-to-point connection, the 10Base-T/ 100Base-TX LAN ports at both ends of the Ethernet LAN tributary board equipped systems are "plug-and-play" devices and no provisioning is necessary, except that they need to be associated with WAN ports at both ends via a Virtual Switch. Under the Repeater mode of operation, a Virtual Switch contains only one LAN port and one WAN port. In this mode no MAC filtering takes place.

The WAN port that supports the Repeater mode requires the provisioning of the following parameters:

1. WAN port capacity (require manual provisioning) at either 2, 4, 6, 8, 10, 50 or 100 Mbit/s
2. Association of the WAN port to a LAN port
3. Create cross-connections between VC-X and TU-X (where X=12 or 3).

LAN-Interconnect Mode

The LAN-interconnect mode of operation offers dedicated WAN bandwidth to a single end-user. Under the LAN-interconnect mode of operation, a Virtual Switch must only contain LAN ports with the same CID (Customer ID) to ensure the entire WAN port bandwidth allocated for the group is dedicated to a single end-user. Any combination of LAN- and WAN-ports is allowed (but with a minimum of two ports to be meaningful).

LAN-VPN Mode

Under the LAN-VPN mode, a number of LAN- and WAN ports are grouped together to form one virtual switch. The Virtual Switch contains LAN ports of multiple end-users sharing the same WAN port(s) bandwidth. To safeguard each individual end-user's data flow and to identify an end-user's VPN from the shared WAN, the Ethernet LAN board equipped system assigns a CID to each LAN port within a Virtual Switch. The CID of each end-user (or LAN port) must be unique within a shared WAN port to create a fully independent VPN. The VPN provisioning on the WAN ports on the access and intermediate nodes is done automatically by the proprietary protocol STVRP (Spanning Tree with VPN Registration Protocol) which runs without operator intervention.

The LAN-VPN mode of operation controls the shared bandwidth by making use of the following features:

SDH WAN bandwidth sharing:

Allows multiple end-users to share the same SDH WAN bandwidth with each end-user being allocated a sub-VC12-Xv (X= 1, 2, 3, 4, 5) or sub-VC3 rate of bandwidth. The

combined end-user bandwidth is then mapped to the SDH time-slots and transported in the SDH network as a single data load. The minimum sub-VC12 rate that can be configured per end-user at a LAN port is 150 kbit/s.

Strict policing/Oversubscription mode: See section Quality of Service.

The LAN-interconnect mode of operation is a special case of LAN-VPN operation where a Virtual Switch contains LAN and WAN ports of a single end-user only. Note the Ethernet LAN tributary board can support both LAN-interconnect and LAN-VPN mode of operations simultaneously as long as a Virtual Switch under each operation mode does not include the same WAN port(s) used by the other operation.

LAN-VPN with 802.1p QoS Mode

This mode is identical to the "normal" LAN-VPN mode, with the addition of the enhanced Quality of Service features described in the Quality of Service section. These features comprise classification into four traffic classes, rate control per flow, rate control per port, and scheduling on egress ports.

Spanning Tree Virtual Switch Mode

The 802.1Q VLAN tagging scheme can be seen as an extension of the LAN-VPN mode, providing more flexibility in defining the VPN’s and in general leading to a more efficient use of bandwidth. In 802.1Q VLAN tagging mode, a virtual switch is formed by a combination of LAN- and WAN ports on a physical switch, that are used by different VLAN's which can share the common WAN bandwidth. Each port can be part of only one virtual switch, but a certain port may be associated with more than one VLAN. VLAN's in the same Virtual Switch are defined by their VLAN Port Member Set. The ports that are associated with a certain VLAN ID form the VLAN Port Member Set. On ingress, each packet is filtered on its VLAN ID. If the receiving port is a member of the VLAN to which a received MAC frame is classified, then the frame is forwarded. If not, then that frame shall be discarded. The user can provision whether untagged packets are dropped, or tagged with a PVID (Port VLAN ID), via the acceptable frame type parameter.

The VLAN trunking example in Figure 4-3 is one of the possible applications in this mode.

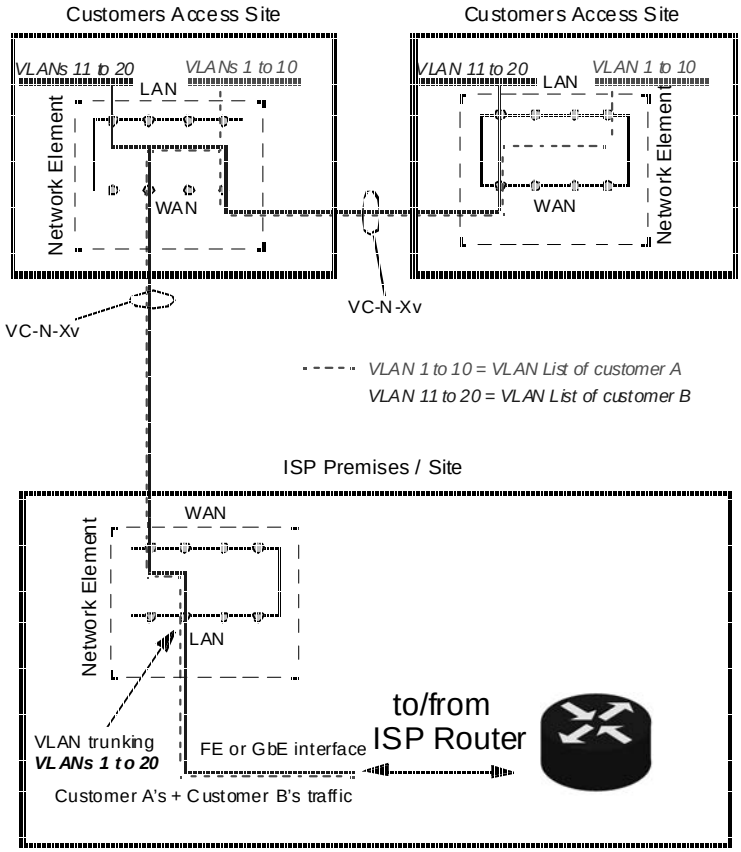


Figure 4-3. VLAN Trunking Application Example

VLAN IDs assigned to LAN Ports should not overlap in case the operator wants to ensure Layer-2 security between those LAN Ports (In many applications, LAN Ports are likely to be dedicated to one customer). It is the responsibility of the operator to define appropriately non-overlapping VLAN IDs on all the created virtual switches. Also the provisioned PVID, with which untagged incoming frames are tagged, should not overlap with any VLAN ID on the virtual switch of which the customers' port is part (again, this is the responsibility of the operator).

Manual provisioning of intermediate nodes can be cumbersome and difficult. Therefore it is recommended to use the auto-provisioning mode for VLAN ID's on the intermediate nodes. A protocol named GVRP (Generic VLAN Registration Protocol provides this functionality. GVRP is an application of the Generic Attribute Registration Protocol (GARP) application, which runs on top of the active spanning tree topology.

IEEE 802.1Q defines two kinds of VLAN registration entries in the Bridge Filtering Database: static and dynamic entries. The static entries can only be entered by the user, the dynamic entries are added automatically by the GVRP protocol. In the Ethernet LAN tributary board implementation, static entries need to be provisioned only on access node's

LAN ports. GVRP will take care of configuring dynamic entries on the WAN ports of intermediate and access nodes.

A spanning tree per virtual switch is implemented. If the user wants the traffic to be protected by the spanning tree protocol and he uses the manual provisioning mode, he must make sure that the WAN ports in the alternative path also will have the corresponding VLAN ID assigned. E.g. in a ring topology, all NE's in the ring must be provisioned with this VLAN ID. In automatic mode, the GVRP protocol will take care of the dynamic VLAN provisioning.

The user has the possibility to flush dynamic VLAN's, thus remove dynamic VLAN's that are no longer used.

For the 802.1Q VLAN tagging mode, the Oversubscription Mode is not supported.

Only independent VLAN learning is supported on the Ethernet LAN tributary board. This means, if a given MAC address is learned in a VLAN, the learned information is used in forwarding decisions taken for that address only relative to that VLAN.

Virtual Switch modes Interoperability

The releases that came after Ruby are all downward compatible, they support the same modes of operation that are present in the Ruby release. Virtual Switches that are configured in the same operational mode can interwork. Virtual Switches not configured in the same operational mode do not interwork in all cases. If a Virtual Switch is configured in the "Repeater" mode or the "STP Switch" mode, it can only interwork with Virtual Switches that are configured in the same mode. Interworking between a remote LAN-interconnect virtual switch and a LAN-VPN virtual switch is not prohibited, because the LAN-interconnect mode can be seen as a special case of the LAN-VPN mode.

Spanning Tree Protocol

Ethernet MAC service does not permit duplication of Ethernet frames between any source and destination end station pair. The potential for frame duplication in a bridged network (e.g., LAN) happens when multiple paths between the source and destination end station pair. When multiple paths exist between any source-destination pair, a loop occurs in the bridged network.

IEEE 802.1D defines Spanning Tree Protocol (STP) to prevent a bridged network (e.g., LAN) from creating network loops. By using the STP, bridges communicate to each other by exchanging Bridge Protocol Data Units (BPDUs) configuring a simple connected active topology. Frames are forwarded through some of the bridged ports (with forwarding state) but not to the ports/segments, which are held in a blocking state. Ports that are in a blocking state do not forward frames in either direction but may be put into a forwarding state should the active topology and path fail. With STP, the algorithm ensures that only

one active path will be used to forward frames from any source port to any destination port. The STP algorithm uses bridge priority, port priority and path cost to compare and select an active path.

The user can track back the path from a NE to the root by successively retrieving the Root Port for each NE in the path. The user can influence the STP choice of root and topology by modifying the bridge/port priority of individual bridges/ports and the path cost of individual links. This influence is indirectly however, the Spanning Tree Protocol itself will evaluate all these parameters to determine the root and calculate a topology.

The STP support in the "TransLAN Network" is invisible to end-users because STP is only applied to WAN ports to resolve loops in the WAN network. The end-user's BPDUs are transported transparently through the "TransLAN Network". Therefore, to end-users connected to the "TransLAN Network" through LAN ports, the "TransLAN Network" appears like a single bridge that does not support STP. See Figure 4-4.

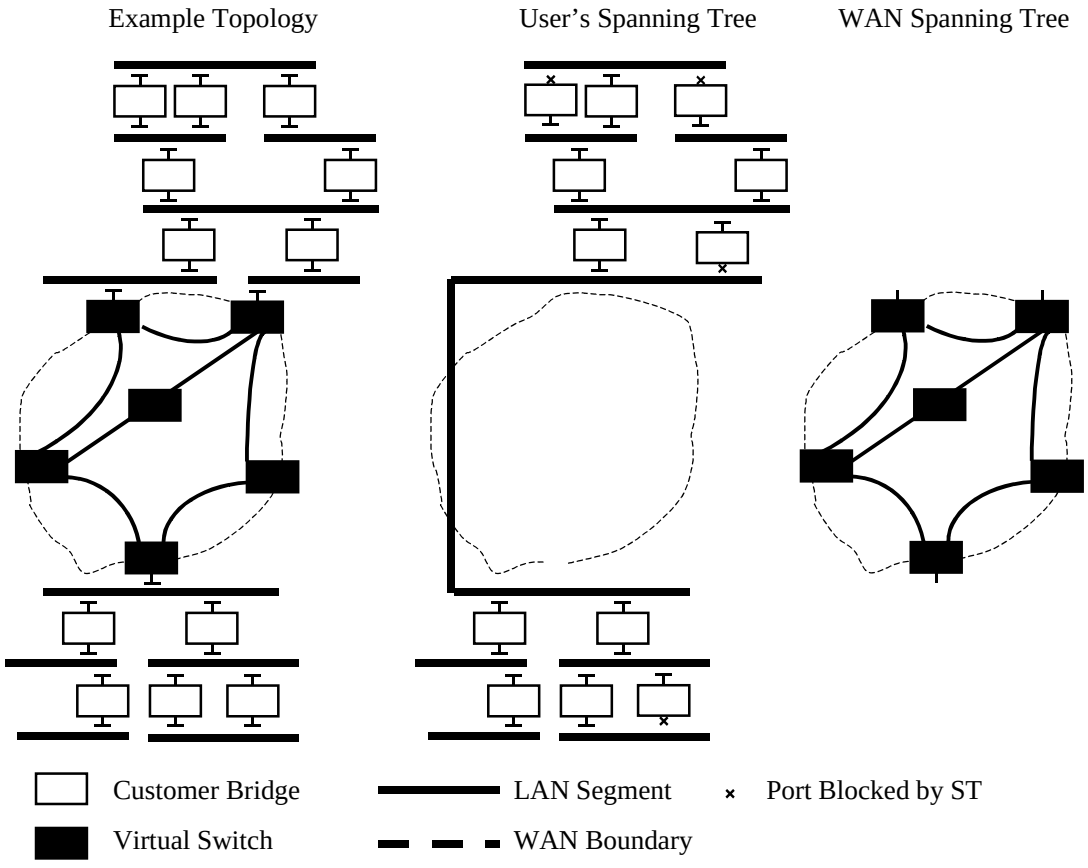


Figure 4-4. Spanning Tree Separation

Consequently, LAN ports of the Ethernet LAN board should not be interconnected without a STP supporting bridge in between in order to avoid loops in the interconnected LAN ports. See Figure 4-5 for examples of wrongly configured networks.

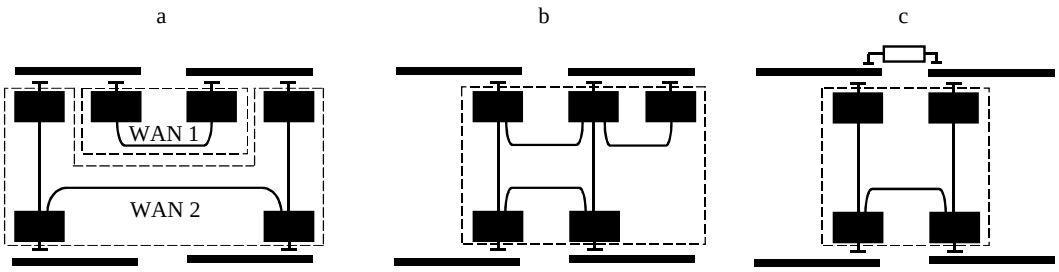


Figure 4-5. Examples of Loops not detected when running ST on WAN Ports only

The Ethernet bridge diameter is defined as the maximum number of nodes between any connection in the active spanning tree topology, the access nodes included. There is an upper limit for the diameter in any practical application. If the diameter exceeds this limit, there is a risk that re-convergence of the spanning tree algorithm in case of a link failure will never be reached.

In the VPN tagging mode the maximum diameter is 20, in the VLAN tagging mode the maximum diameter is 40.

The Ethernet LAN tributary board supports a single STP per Virtual Switch under LAN-Interconnect mode and a single STP per VPN under the LAN-VPN mode. In the STP Virtual Switch mode, the Ethernet LAN tributary board supports a single STP per Virtual Switch. When operating in the Repeater mode, the Ethernet virtual bridge (an instance of the TransLAN Ethernet bridging function) must not participate in a STP.

In the STP Virtual Switch mode, a number of STP status parameters per Port/Virtual Switch are retrievable/editable. The most important ones are the support of Port State retrieval and the support of Bridge/Port Priority provisioning.

The Port State can have one of the following values:

Disabled - The port is disabled completely.

Blocking - BPDUs and normal frames are discarded.

Listening - BPDUs are processed, but normal frames are discarded. The Filtering Database is not updated.

Learning - BPDUs are processed, but normal frames are discarded Received. BPDUs are used to learn addresses and update the Filtering Database.

Forwarding - BPDUs are processed and normal frames are forwarded.

Path Cost provisioning:

The system sets a default STP path cost for each link which is inverse proportional to the speed (2, 4, 6, 8, 10, 50 and 100 Mbit/s). BPDUs are capable of carrying 32 bits of Path Cost information; however, IEEE Std. 802.1D, 1998 edition and earlier revisions of this standard limited the range of the Path Cost parameter to a 16-bit unsigned integer value. The recommended values in IEEE Std. 802.1t-2001, make use of the full 32 bit range available in BPDUs in order to extend the range of link speeds supported by the protocol. In LAN's where bridges that use the recommended values defined in the IEEE Std. 802.1D, 1998 edition and bridges that use the recommended values in IEEE Std. 802.1t-2001 are required to inter-operate, either the older Bridges or the new Bridges need to be reconfigured to make Path Cost values compatible. However, this situation is not likely to occur since the first release of STP in IEEE 802.1Q tagging will support the values recommended in IEEE Std. 802.1t-2001.

Bridge Priority provisioning:

Ranges and granularities for Port Priority defined in IEEE Std. 802.1D, 1998 edition have been modified in IEEE Std. 802.1t, 2001 edition: value range should now be expressed in steps of 4096 instead of 1. The step values chosen ensure that the low-order bits that have been re-assigned cannot be modified (Bridge priority 12 low-order bits have become a 12-bit system ID extension for Multiple Spanning Trees). The magnitude of the priority values can be directly compared with those based on previous versions of the standard, which ensures full interoperability. Although the NE and management systems support a granularity of 1, it is advised to provision a Port Priority with the new granularity of 4096 in order to ensure interoperability.

Port Priority provisioning:

Ranges and granularities for Port Priority defined in IEEE Std. 802.1D, 1998 edition have been modified in IEEE Std. 802.1t, 2001 edition: value range should now be expressed in steps of 16 instead of 1. The step values chosen ensure that the low-order bits that have been re-assigned cannot be modified (Port priority 4 low-order bits are now considered to be part of the Port Number). The magnitude of the priority values can be directly compared with those based on previous versions of the standard, which ensures full interoperability. Although the NE and management systems support a granularity of 1, it is advised to provision a Port Priority with the new granularity of 16 in order to ensure interoperability.

Quality of Service

Quality of Service is supported on the Ethernet LAN tributary board. It is implemented as a DiffServ architecture applied to layer 2. See Figure 4-6 for an overview of the implemented functional blocks.

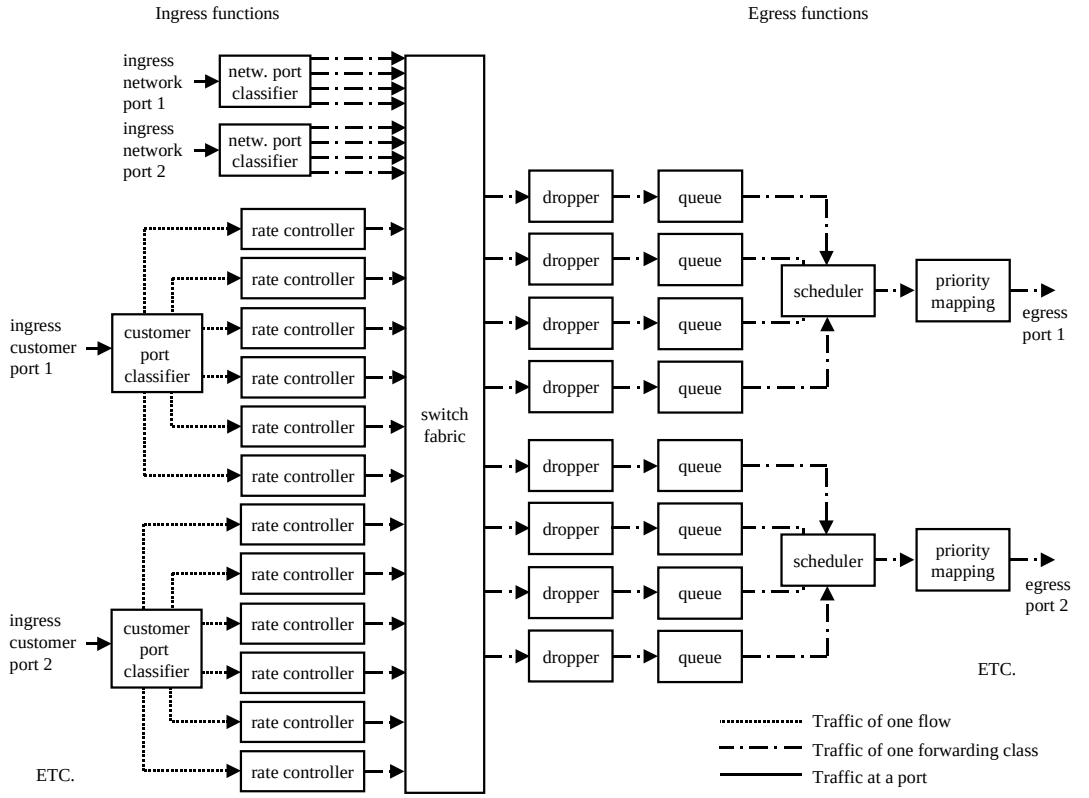


Figure 4-6. QoS Functional Blocks

Table 4-3 gives an overview of the QoS Capabilities per Virtual Switch Operational Mode.

Table 4-3. Overview of the QoS Capabilities per Operational Mode

Operational Mode	Flow Classification on Ingress	Rate Controlling per Flow	Scheduling on Egres
Repeater	**N/A**	**N/A**	**N/A**
LAN-Interconnect/LAN-VPN	**Per Port**	**None, Strict Policing, Oversubscription**	**One Queue**
LAN-VPN with IEEE QoS	**Per Port per User Priority per VLAN**	**None, Strict Policing, Oversubscription**	**Four Queues, (Strict Priority or Weighted Bandwidth per Queue)**
STP Virtual Switch	**Per Port per User Priority per VLAN**	**None, Strict Policing**	**Four Queues, (Strict Priority or Weighted Bandwidth per Queue)**

On the WaveStar® ADM 16/1 the responsibility for admission control is left to the operator. This means there is no check that the Service Level Agreements on already existing connections can be fulfilled, when a new user starts sending data from node A to B. In this respect the notion of over-subscription factor is important. This is the factor by which the calculated bandwidth, based on e.g. the traffic matrices of the operators sharing a link, exceeds the physically available bandwidth. Although theoretically the bandwidth can only be guaranteed for an over-subscription factor <= 1, in practice an over-subscription factor of 5-10 can be used without giving problems. Due to the effects of statistical multiplexing it is safe to "sell the bandwidth more than once". The burstiness of the traffic from individual customers that share a common link makes this possible. The Service Level Agreements give a quantification for the "statistics" of the multiplexing.

The provisioning of the classifier and rate controller per flow is done only on the ingress customer port. On the network ports, only the scheduler for the egress queues is provisionable.

It is important that some of the QoS settings are provisioned consistently on all ports throughout the whole customer's VPN domain. For the rate controller the mode = none/ strict_policing/over-subscription (per virtual switch),

for the scheduler for each egress queue the mode = strict_priority/weighted_bandwidth and corresponding weights (per virtual switch) must be provisioned consistently.

Classifier

The classifier will determine into which flow each incoming packet is mapped. On customer port ingress, a number of flows can be defined, based on port, user priority, and optionally VLAN ID, but the mapping towards egress queue is fixed and based on the user priority only. For each flow a rate controller (CIR/PIR value on LAN ports only) can be specified. If the classifier operational mode is set to mapping-table, each flow will be mapped to a traffic class based on the value of the user priority only, using a fixed table. Each traffic class is associated with a certain egress queue. Apart from these flows based on input criteria, a default flow is defined for packets that do not fulfil any of the specified criteria for the flows, e.g. untagged packets which have no user priority field. If the user specifies the default_overriding mode, all incoming packets will go into the default flow and are treated the same. The user can specify on port level the default user_priority to be added to each packet in the default flow, and the rate controller behavior for the default flow. The same fixed mapping table from user priority to traffic class to egress queue is applied to packets in the default flow as to packets in the specified flows.

See Table 4-4 for the mapping of user priority to traffic class to egress queue on a customer port. Once the traffic class/egress queue is set for a certain packet at the ingress customer port, the packet will keep the same traffic class/egress queue throughout the network. A customer should make sure that his packets are marked with the appropriate user priority, if he wants to use this flow classification, or use the default_overriding mode otherwise.

Table 4-4. Fixed Mapping of User Priority to Egress Queue on Customer Ports

User Priority	Traffic Class	Egress Queue
0 (000)	1	2
1(001)	0	1
2(010)	0	1
3(011)	1	2
4(100)	2	3
5(101)	2	3
6(110)	3	4
7(111)	3	4

Note that the egress queue number is not linear increasing with user priority. This mapping is according to IEEE802.1Q Table 8-2 (case of four traffic classes).

Rate Controller

The rate controller is a means to limit the users access to the network, in case the available bandwidth is too small to handle all offered ingress packets. Rate control is supported for every ingress flow on every LAN port.

On the Ethernet LAN tributary board a "color unaware one-rate two-color marker" is supported, which can be seen as a degenerate case of the two-rate three-color marker. "Color un-aware" meant the user cannot provision the packets with a certain dropping precedence. Marking will be done only by the rate controller itself.

A two-rate three-color marker is defined by thee colors, specifying the dropping precedence, and two rates as delimiter between the colors. The marker will mark each packet with a certain color, depending on the rate of arriving packets, and the amount of credits in the token bucket. The size of the token bucket will determine how long and far a rate may be surpassed before the packets are marked with a higher dropping precedence.

The three colors indicate:

- Green - low dropping precedence
- Yellow - Higher dropping precedence
- Red - The packet will be dropped

The two rates mean:

- Committed Information Rate (CIR): Delimiter between green and yellow packets
- Peak Information Rate (PIR): Delimiter between yellow and red packets

The one-rate-two-color marker that is currently implemented can operate in two different modes. The Strict Policing Mode is defined by CIR=PIR and the Over-subscription Mode is defined by PIR = Infinite. The size of the token buckets is implemented as a fixed percentage of the corresponding rate and is not provisionable.

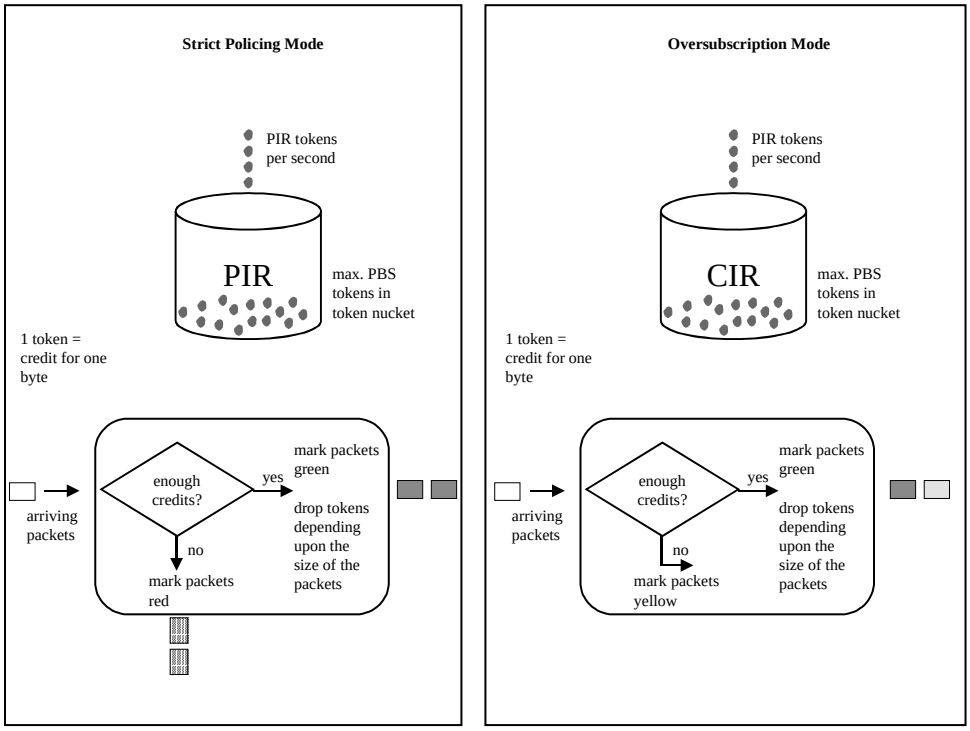


Figure 4-7. One-RateTwo-Color Marker

· **No policing**: In this mode effectively no policing is taking place. This mode allows each end-user to offer the maximum committed SDH WAN bandwidth. Any additional incoming frames at the ingress LAN port that would exceed the physical network port bandwidth will be dropped. The user has no influence on which packets are dropped. In this mode effectively applies that CIR=PIR=MAX.

· **Strict policing mode**: This mode allows each end-user to subscribe to a minimum committed SDH WAN bandwidth, or CIR (committed information rate). This mode will guarantee the bandwidth up to CIR but will drop any additional incoming frames at the ingress LAN port that would exceed the CIR. All packets below CIR are marked green, all packets above CIR are marked red and dropped. Note CIR only concerns the Ethernet frame payload; therefore, we recommend the use of layer 3 traffic rate to define the required CIR at service level. In this mode effectively applies that CIR<=MAX, CIR=PIR.

· **Over-subscription Mode**: This mode allows end-users to burst their data flow to a maximum available WAN bandwidth at a given instance. When PIR is set to equal to MAX, the physical network port bandwidth, an end-user is allowed to send more data than the specified CIR. The additional data flow above CIR is tagged with the "drop precedence bit" being set to a higher drop probability. All packets below CIR are marked green, all packets above CIR are marked yellow. In this mode effectively applies that CIR<=PIR, PIR=MAX.

Dropper

The dropper function will decide whether to drop or forward a packet. On the Ethernet LAN tributary board a deterministic dropping from tail when the queue is full is implemented. Packets that are marked red are always dropped. If WAN Ethernet Link congestion occurs, frames are dropped. Yellow packets are always dropped before any of the green packets are dropped. This is the only dependency on queue occupation and packet color that is currently present in the dropper function. No provisioning is needed.

Scheduler

The preceding functional blocks assure that all packets in the four queues can be handled by the scheduler, no further packets need to be dropped. The order in which packets from the four queues are forwarded, is determined by the scheduler.

The scheduler on each of the four egress queues can be in two operational modes, strict priority or weighted bandwidth. Any combination of queues in either of the two modes is allowed. When exactly one queue is in weighted bandwidth mode, it is interpreted as a strict priority queue with the lowest priority. Normally the queue with the lowest number also has the lowest ranking order, but this ranking order of the strict priority queues may be redefined by the user. It is recommended not to change the mode and ranking of the queue with the highest number (=4) however, because this queue is also used by protocol packets like spanning tree BPDU's and GVRP PDU's.

Strict Priority Mode

The packets in strict priority queues are forwarded strictly according to the queue ranking. The queue with the highest ranking will be served first. A queue with a certain ranking will only be served when the queues with a higher ranking are empty.

Weighted Bandwidth Mode

The weights of the weighted bandwidth queues will be summed up; each queue gets a portion relative to its weight divided by this summed weight, the so called normalized weight. The packets in the weighted bandwidth queues are handled in a Round-Robin order according to their normalized weight.

Each of the two modes has his well-known advantages and drawbacks. Strict Priority queues will always be served before Weighted Bandwidth queues. So with strict priority, starvation of the lower priority queues cannot be excluded. Starvation should be avoided by assuring that upstream policing is configured such that the queue is only allowed to occupy some fraction of the output link's capacity. This can be done by setting the strict policing rate control mode for the flows that map into this queue, and specifying an appropriate value for the CIR. The strict priority scheme can be used for low-latency traffic such as Voice over IP and protocol data such as spanning tree BPDU's or GVRP PDU's.

Weighted Bandwidth queues are useful to assign a guaranteed bandwidth to each of the queues. The bandwidth can of course only be guaranteed if concurrent strict priority queues are appropriately rate-limited. The assigned weight factor represent 256-byte quanta in the weighted Round-Robin algorithm. To reduce burstiness between the queue transmissions, the user should strive for minimal weight factors, which are however bigger than the maximum length of a packet. This will be achieved by a weight factor of at least six (6*256>1500).

Performance Monitoring

On the VC3/VC12 termination points that are connected to a WAN port, the "normal" performance monitoring can be activated. The same counters that apply for VC3/ VC12TPs on any other port also apply to the VC3/VC12 TP’s on a WAN port.

Apart from this standard SDH PM, a limited amount of counters that are dedicated to LAN/WAN ports are defined. Activation of these counters can be established by setting the LAN port mode to monitored, selecting a LAN port or WAN port as active PM point, and setting the PM point type to LAN or WAN.

The supported dedicated parameters are:

- CbS (total number of bytes sent)
- CbR (total number of bytes received)
- pDe (packets in error dropped)

Note that CbS and CbR are rather traffic monitoring counters than performance monitoring counters, as they give insight in the traffic load in all places in the network. pDe is a real performance monitoring counter as it gives an indication about the performance of the network. Only unidirectional PM is supported for these parameters. See Figure 4-8 for the location of the measurements. Note that because of the difference in units, bytes versus packets, the counters cannot be correlated with each other. Also the counter for dropped packets considers only packets dropped due to errors, and does not include packets dropped due to congestion.

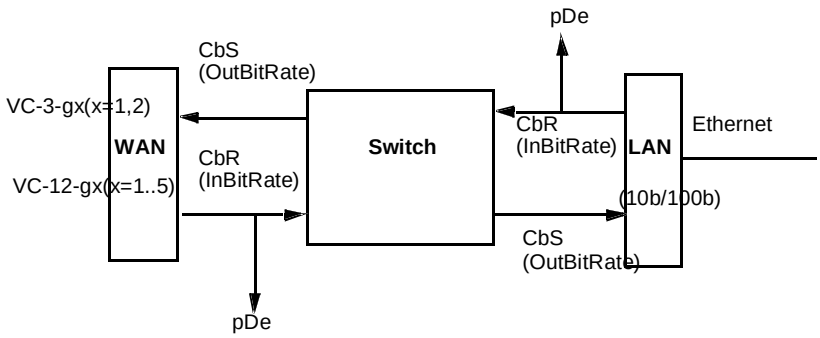


Figure 4-8. Performance Monitoring Counters

1000BASE-X Ethernet LAN tributary board; IP-GE/ 2, (LJB460)

The Gigabit Ethernet interface supports 1000BASE-SX optical interfaces or 1000BASE-LX optical interfaces according IEEE 802.3 Clause 38. Full duplex only is supported. SX or LX applications can be selected by Small Formfactor Plugable module based Gigabit Ethernet interfaces.

Note: On WaveStar® ADM 16/1 the 1000BASE-X tributary card is only supported in combination with Ruby controller hardware (LJB475B) or later.

For basic Ethernet features please refer to the previous chapter Ethernet LAN tributary board, IP-LAN 8 Tlan, (LJB459). On the following page 1000BASE-X specific features are listed.

- Gigabit Ethernet mapping type for VLAN Trunking (single/dual LAN port, single card)
- Gigabit Ethernet mapping type for Gbe “lite” (single LAN port, single card)
- Ethernet mapping type for WAN-to-WAN grooming/aggregation (single card)
- Mapping of Ethernet MAC frames into VC-4-Xv (GFP encapsualtion)
- Mapping of Ethernet MAC frames into (LO) VC-3-Xv (GFP encapsualtion)
- Mapping of Ethernet MAC frames into (LO) VC-3-gv (EOS encapsualtion)
- LAN bridge mode on Gigabit Ethernet Hardware
- LAN promiscuous mode on Gigabit Ethernet Hardware
- Multi-port LAN Bridging mode with L2 VPN support for Gigabit Ethernet
- Layer 2 VPN Data Policing, for Gigabit Ethernet
- Port-based VPN Customer Tagging, for Gigabit Ethernet (Transparent aka double tagging)
- IEEE 802.1Q VLAN Tagging (Gigabit Ethernet)
- Gigabit Ethernet VLAN Trunking

- VLAN Trunking: Fast Ethernet WAN to Giagbit Ethernet LAN
- LCAS for Ethernet (1000BASE-X “lite”)
- Performance Monitoring on LAN connections (Gigabit Ethernet ports)

Timing and Synchronization Interface Circuit Packs

Two types of timing and synchronization interface circuit packs are available to provide extra external synchronization in- and outputs with a specific format (besides the station clock in- and outputs on the interconnection box). These boards must be mounted behind the power and timing circuit packs. The synchronous paddle boards’ internal (that is towards the WaveStar® ADM 16/1 system) output signal of 2048 kHz, is dual fed to both power and timing circuit pack slots.

The following timing interface circuit pack is available for DS0 and DS2 markets (Japan and USA):

- TI-DS2DS0/1: Combined 64 + 8 kHz Sync Input + 6312 kHz Sync Output pack

  Contains hardware to transform the external 64 + 8 kHz composite clock signal into the internal 2 MHz station clock signal. This board also contains hardware to transform the internal 2 MHz station clock signal into an external 6312 kHz sinusoidal output clock signal. One input and one output channel per pack.

E4/STM-0/STM-1 Circuit Packs

The **SPIA-1E4/4B** or **SIA-1/4B** circuit packs supports a maximum of 4 x STM-1 signals. By using the correct electrical or optical paddle board and by correct provisioning of the unit, the card supports STM-1 electrical or STM-1 optical interfaces.

For 140 Mbit/s interfaces electrical paddle boards should be mounted behind the **SPIA-1E4/4B** card.

The **SA-0/12** is needed to support a maximum of 12 x STM-0 signals. The STM-0 optical interfaces themselves are located on separate optical Interface Circuit Packs (see above) and must be mounted directly behind the SA-0/12 card.

AU-3 / TU-3 Conversion

STM-1 tributary circuit packs, **SPIA-1E4/4B** or **SIA-1/4B**, support remapping of VC-3 from AU-3 to TU-3 and vice versa (AU-3/TU-3 conversion):

- AU-3 <-> VC-3 <-> TU-3 <->TUG-3 <->VC-4 <->AU-4

In this way, AU-3 structured signals will be translated into TU-3/AU-4 structured signals that can be handled by the cross-connect of the WaveStar® ADM 16/1 system.

STM-4 optical interface cards support the same AU-3/TU-3 conversion as described above for the STM-1 tributary board. Conversion is selectable per “STM-1”.

The **SA-0/12**, supports the following conversion mode:

- AU-3 <-> VC-3 <-> TU-3 <->TUG-3 <->VC-4 <->AU-4

Cross-connect circuit pack

The CC-64/16 or CC-64/32(B) is connected with the Interface circuit packs via the backplane bus. The higher order cross-connect size is equivalent to 64 x 64 STM-1s (VC-4s); the lower order cross-connect size is up to 32 x 32 STM-1s (VC-4s)(CC-64/32). The lower order part is also called time slot interchanger (TSI) because it can interchange the location of TU-3s and TU-12s within the VC-4s.

The WaveStar® ADM 16/1 can provide optional equipment redundancy (1+1) for the cross-connect circuit pack.

The fixed cross-connect unit replaces the working cross-connect unit, the protection cross-connect slot remains unassigned, as well as one of the tributary slots. No equipment protection of tributary cards is supported, nor of line cards or cross-connect units. Only the power and timing unit can be protected. Network protection schemes like MSP, MS-SPRING or SNCP are not supported either.

Power and Timing circuit packs

The WaveStar® ADM 16/1 can be equipped with two Power and Timing circuit packs (PT): one as a working generator and the other as standby.

Two versions of PT are available:

- PT-stnd:Standard version with approximately 4.6 ppm stability
- PT-str3:Version with approximately 0.37 ppm stability for the first 24hours of hold-over.

Timing modes available:

- Free running
- Hold-over
- Locked with reference to:
  - one of the external sync. inputs
  - one of the STM-N inputs
  - one of the 2 Mbit/s tributary inputs

The PT circuit packs also perform the necessary power filtering functions to meet the ETSI requirements. To maintain high availability, these circuit packs may be duplicated (however, the system still works properly with only one PT inserted).

The actual DC/DC conversion is located on the circuit packs. The power feeds remain duplicated between the PT and the circuit packs.

System controller circuit pack

The System Controller (SC or the new SC2 in R4.0, Ruby-2) controls and provisions all circuit packs, via a duplicated LAN bus. It also controls the user panel (located at the front of the SC) and provides external operations interfaces.

The SC has a certain amount of alterable non-volatile memory for storage of programs, configuration and other semi-permanent data for the DPS (on-board the SC) and all Function Controllers (FCs) in the system; this is the local WaveStar® ADM 16/1 database. After initial power-up, the SC assumes default parameters for some configurable items (e.g. CIT bit rate). Volatile memory is needed to store temporary data structures. It is possible to download software from the WaveStar® ITM-SC to the SC to replace or add applications in the local database.

During download the old software is stored in memory as a back up. This means that after download, two complete software versions are available on the SC.

The following external interfaces are provided by the SC:

- **Miscellaneous discretes** (8 x Input, 4 x Output), via a management system
- Station Alarm Interfaces
- **Q-LAN 10 Base-2 interface** (for network and network element level management)
- **Q-LAN 10 Base-T interface** (for network and network element level management)
- **2 x F interface (rear and front access)** (for local network element management and maintenance)
- **4 x G.703 and 2 x V.11 interfaces** (Data and/or engineering order wire).

The Q-LAN address is derived from the dip-switch settings on the SC.

Timing and Synchronization

Timing Architecture of the WaveStar® ADM 16/1

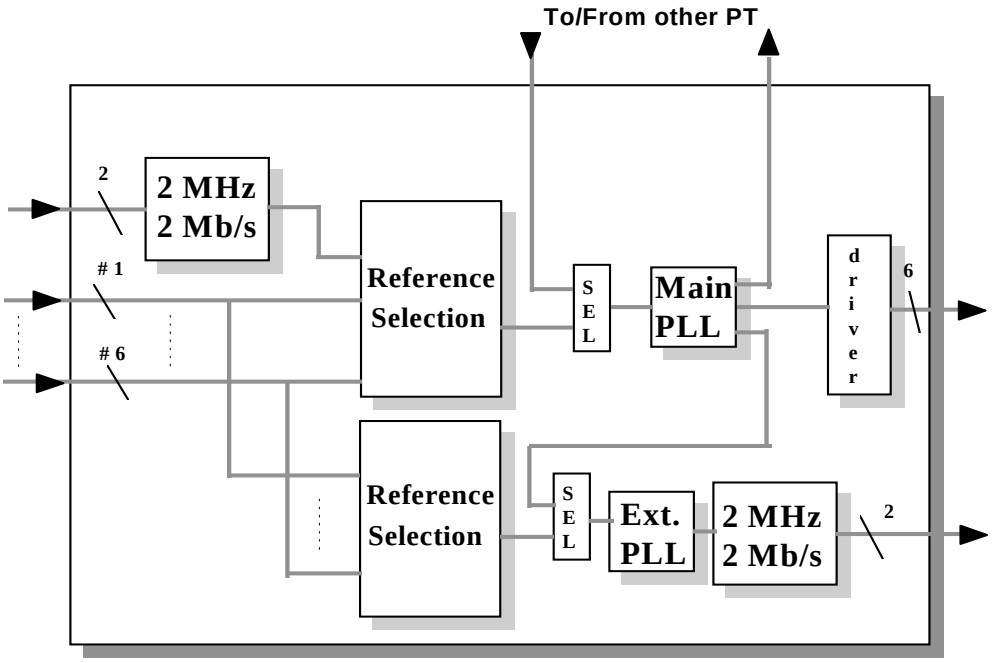


Figure 4-9. Power and Timing Architecture

Figure 4-9 depicts the architecture of a power and timing circuit pack (PT) of the WaveStar® ADM 16/1 System, a maximum of two of which can be present in a system. A 1+1 equipment protection scheme can be set up between the two PTs.

Eight timing reference inputs (2 + 6) are shown. These inputs have the following function:

- 2 x External timing inputs (external station clock): 75 or 120 Ω (selected by different wiring of the cable connectors), 2 Mbit/s or 2 MHz.
- 6 x Internal timing reference inputs divided as follows:
  - 4 x Tributary (2 Mbit/s or STM-1 tribs)
  - 2 x Line

Note: an MSP pair counts as a SINGLE timing reference!

Eight timing reference outputs (2 + 6) are shown. These outputs have the following function:

- 2 x External timing outputs (external station clock): 75 or 120 Ω (selected by different cabling), 2 Mbit/s or 2 MHz.
- 6 x Internal timing reference outputs divided as follows:

- 4 x Tributary (2 Mbit/s or STM-1 tribs)
- 2 x Line.

Note: by software selection the user may choose to forward the external timing output signal to the first, the second or both timing output signal connectors.

Two PLLs (phase lock loops), or station equipment clocks (SECs), are shown: one is the main PLL; the central clock driving six timing output ports, and the other the External PLL, driving two timing output ports.

The signal driving the individual PLLs can be selected as follows:

- for the MAIN PLL: out of either the sync. signal provided by the other (protect) PT-circuit pack or out of the reference signal selected by the reference selector shown to its left.
- for the EXT. PLL: out of either the sync. signal provided by the MAIN PLL or out of the reference signal selected by the reference selector shown to its left.

Hence it is possible to select individual timing references for the outgoing station clock signals and for the internal reference clock signals. Reference selections are software selectable by the user.

Timing modes

As shown in figure 4-10, the system can be provisioned for the following synchronization conditions / modes:

- Add/Drop or Terminal application:
  - Free running from an internal oscillator (FR)
  - Internal Timing from an incoming line or tributary signal (lower order)
  - External Timing, timed from an external 2 MHz or 2 Mbit/s clock signal (lower order)
  - Hold-over mode (HO).

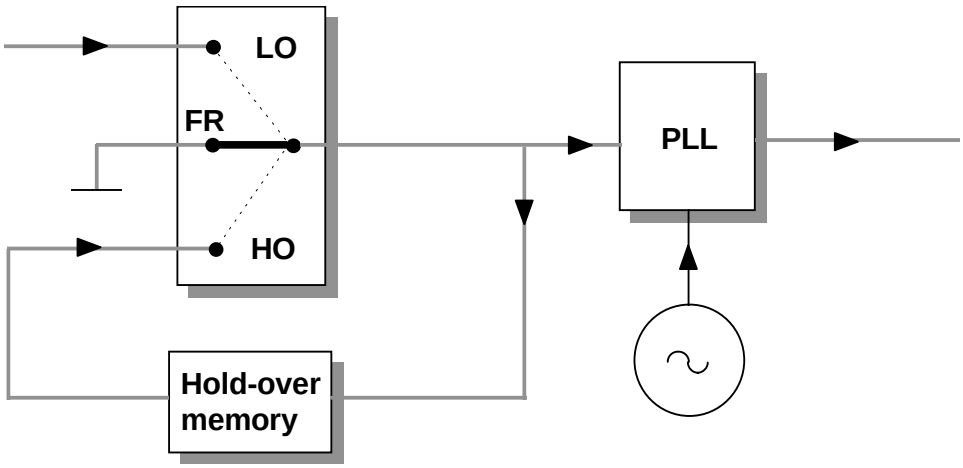


Figure 4-10. Timing Modes (Free running selected)

The user can select the system to function in any one of the three sync. modes specified above. This selection can be done by software (user input) or be fully automatically. If set to automatic, the system will automatically switch to hold-over mode if the input timing reference signal fails.

Free Running operation (FR)

The WaveStar® ADM 16/1 is designed to operate without any external synchronization reference in the free running mode. In the free running mode (switch set to FR in figure 4-10), the PT derives timing from an internal station equipment clock (SEC) oscillator. The internal SEC oscillator's long-term accuracy is higher than 4.6 ppm. The PT generates and distributes the timing signals to the interface circuit packs.

Locked mode (LO)

- Locked-to-line or tributary operation (with hold-over).

  In the locked-to-line or tributary timing mode (switch set to LO in figure 4-10), the system derives timing from the incoming line or tributary signals. In turn, the PT generates timing signals and distributes them to the transmission circuit packs.

  The signal references are continuously monitored for error-free operation. If the working line or tributary reference in a protected system becomes corrupted, the PT circuit selects the protection line / tributary reference without causing service degradation. If both references fail, the PLL circuit holds the on-board oscillator frequency at the last good reference sample while the references are repaired, (hold-over mode: switch set to HO in figure 4-10 automatically!). This mechanism is provided so that operation with or without an external clock can be easily accommodated.

In both timing modes, the PT can also provide two synchronization outputs to other central office equipment.

- Locked to External timing reference Operation (with hold-over)

  In the external timing mode (switch set to LO in figure 4-10), each PT circuit pack accepts a 2 MHz or 2 Mbit/s synchronization reference signal from a 4.6 ppm or better station clock. These references synchronize the local terminal. Within the PT circuit pack, a highly stable PLL circuit removes any transient impairments from the 2 MHz or 2 Mbit/s reference for improved jitter performance.

  If the external reference fails, the PLL circuit on the PT circuit pack holds the on-board oscillator frequency at the last reference sample while the external clock signal is repaired (hold-over mode: switch set to HO in figure 4-10 automatically!).

Hold-over mode (HO)

As described above, the system provides a so-called hold-over mode to ensure that the timing of the system is as accurate as possible when all timing references fail. It therefore memorizes the most recently used timing frequency in a hold-over memory on-board the PT.

Two versions of PT circuit packs are available with the only difference of hold-over accuracy:

- PT-stnd: the standard PT circuit pack providing a clock to the system with 4.6 ppm hold-over accuracy.
- PT-str-3: the PT circuit pack providing a clock signal to the system with 0.37 ppm hold-over accuracy during at least the first 24 hours of hold-over.

Back-up timing

To keep the software on all circuit packs alive when there is no synchronization signal from one or both PTs, the System Controller (SC) distributes a back-up timing signal. This timing allows for the execution of circuit pack tests and equipment loop-backs. The SC timing signal is distributed to all slots of the system, except for the PT slots. The accuracy of the back-up timing signal is approximately 50 ppm. When the back-up clock is selected, the circuit packs switch all transmission ports to SQUELCH mode.

Clock / Synchronous distribution on circuit packs

Timing at Circuit Pack Level

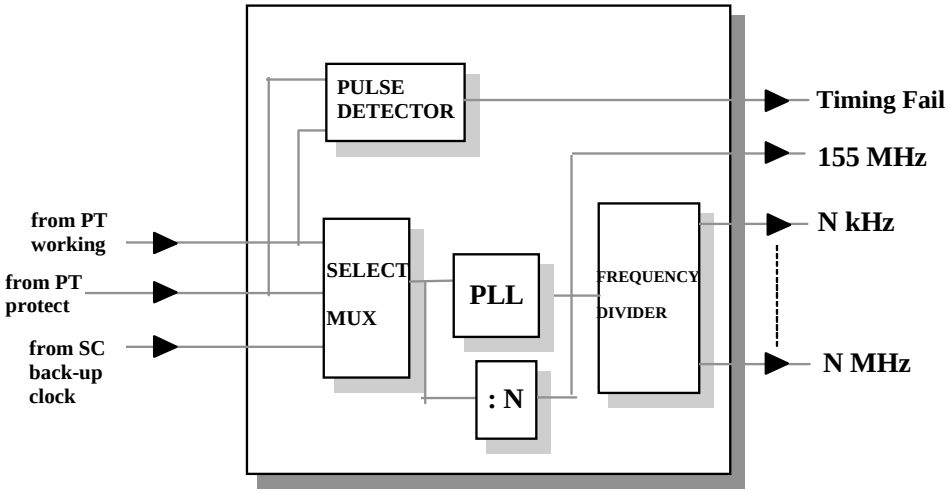


Figure 4-11. Timing at circuit pack level of the WaveStar™ ADM 16/1.

Figure 4-11 gives an overview of timing at circuit-pack level.

A selection is made between one of the following three timing sources:

4. Reference signal selected by the working PT circuit pack
5. Reference signal selected by the protecting PT circuit pack
6. Back-up clock signal derived from the SC.

All PT signals are checked for availability and if a signal fails then message ‘Timing Fail’ (including appropriate source that’s missing) is sent to the on-board function controller (FC). Then the FC immediately initiates the command to switch to the system’s back-up timing and all transmission ports are switched off (squelch mode). Switching between the input references is non-revertive.

A PLL on the circuit pack itself locks to the selected timing source and supplies the circuit pack with all necessary frequencies.

Redundancy and Protection

Equipment Protection (Redundancy)

To enhance the over-all reliability of the system, equipment redundancy can be applied. The FIT rate numbers are specified for each unit in section 10 of this manual.

The core of the system functionality, the cross-connect (CC) circuit pack, can be duplicated if so required. It avoids a single point of failure for traffic between any two port units. A switch-over between cross-connect units, causes a hit in the traffic of at most 50 ms.

In addition, the power and timing (PT) circuit pack can be optionally duplicated. This will provide the necessary power and timing redundancy. If the timing of a single PT circuit pack fails, the back-up PT unit takes over. A switchover of power or timing functions between both PT units, does not affect the traffic through the system.

Although the PT unit can be used in unprotected, it is strongly advised to use the PT circuit pack in redundant mode.

To complete equipment redundancy, all electrical tributary interface circuit packs can be provided with equipment protection as well:

- 1.5, 2 Mbit/s Interface circuit packs can be 1:n (n=max. 8) equipment protected
- 140 Mbit/s and STM-1e circuit packs can be 1:n (n=max. 4) protected
- 34/45 Mbit/s and 45 Mbit/s circuit packs will be 1+1 equipment protected.

In the event of failure in any circuit of an interface circuit pack, all traffic carried by this pack is switched to the protecting circuit pack.

Network Protection

Protection against failures at the network level, e.g. cable breaks or failures in other equipment in the network, requires network level protection schemes. The WaveStar® ADM 16/1 system supports the following network level protection schemes:

1. Multiplex section protection (MSP)
2. Multiplex Section Shared Protection Ring (MS-SPRing)
3. Sub-network connection protection (SNCP)

In addition a number of features are supported to optimize the network protection for many applications:

1. Access of protection bandwidth in MS-SPRing
2. Tailoring of the MS-SPRing bandwidth (selective MS-SPRing)
3. Dual node interworking with drop & continue

At the network level these features allow to make the most efficient use of the available bandwidth, while still providing adequate protection for a very large number of applications.

Multiplex Section Shared Protection Ring (MS-SPRing)

MS-SPRing is a shared protection mechanism, which means that the protection bandwidth is shared by multiple connections. MS-SPRing can operate in a ring network only and it operates at the VC-4 level. The protection is applicable from the node where the VC-4 enters the ring till the node where the VC-4 leaves the ring. The WaveStar® ADM-16/1 supports 2 fiber MS-SPRing on its STM-16 aggregate interfaces, so it supports 2 fiber MS-SPRing protected STM-16 rings. The maximum number of nodes in the MS-SPRing can be 16, the minimum can be 2. The MS-SPRing protocol uses an APS channel for signalling, which is transmitted in K1/K2 bytes in the Multiplex Section overhead, according to ITU-T Recommendation G.841. The protocol provides protection within 50 ms.

In MS-SPRing protected rings it is useful to define (bi-directional) channels. There are 16 such channels in an STM-16 MS-SPRing. A channel can be thought of as the capacity of a single, bi-directional, STM-1 going fully around the ring in a certain fixed position within the STM-16 connections that make up the ring. Each channel can transport one VC-4 payload in both directions at a time If a VC-4 is added/dropped from the channel in a node, it can pick up a new VC-4 there and carry it further around the ring. These channels can be numbered #1 through #16.

In the MS-SPRing the channels #1 through #8 are available for protected VC-4 traffic. They are protected by the capacity provided by channels #9 through #16, on a pair-by-pair basis, so channel #9 protects channel #1, #10 protects #2, etc. up to channel #16 protecting #8. In the Sapphire and later releases, it is allowed to decide per channel pair (1,9), (2,10) etc. whether or not it is part of the MS-SPRing (selective MS SPRing or NUT/NPPA). An application for this exclusion of a certain pair from MS-SPRing could be to avoid double protection on an connection that is already VC-4 SNC protected and thus save bandwidth.

To summarize, within an MS-SPRing the bandwidth can be split in three parts: Worker capacity, protection capacity and un-protected capacity. Each channel pair can be unprotected pair or a worker/protection pair. In the latter case the lower channel number represents the worker capacity and the higher channel number the protection capacity.

The protection capacity can be accessed and used for transport of low priority traffic (“extra traffic”), to utilize the bandwidth even better. Under failure conditions this traffic will be lost (“pre-empted”).

At the network level, the efficiency of the MS-SPRing protection mechanism is its most obvious advantage. The degree of bandwidth saving over e.g. a VC-4 SNCP scheme depends on the traffic pattern. The most dramatic improvement is in the case where the traffic is mostly between adjacent ring nodes. On the other hand, if all traffic is destined for a specific hub-node, there is no bandwidth advantage compared to VC-4 SNCP. For uniform traffic patterns the result is between these extremes.

1+1 Multiplex Section Protection (MSP)

1+1 Multiplex section protection is a relatively simple scheme to protect an STM-N link between two adjacent SDH network elements (excluding regenerators) by providing dedicated protection capacity. The MSP protocol exists in different versions: G.841/Clause 7 (mostly used internationally), G.841/Annex B (Japan) and SONET-style, according to ANSI T1.105 and Telcordia GR-253-CORE (US, Canada). To maximize the interworking and application possibilities, the WaveStar® ADM-16/1 supports all these versions on various STM-N interfaces.

The following parameters can be provisioned and commands can be issued for each 1+1 MSP protection process:

- Operation: Revertive operation or Non-revertive operation. Revertive operation means that after repair of a failure the traffic is switched back to the “worker” capacity. Non-revertive operation
- Wait-to-Restore time. The time that should elapse before a switch back to “worker” is initiated after repair of a failure. The timer can be provisioned between 0 and 60 minutes in 1 minute increments. The default is 5 minutes. Only available with revertive operation.
- Control: Bi-directional or Uni-directional control. Uni-directional control means that each receive end decides separately which traffic stream is active. Bi-directional control means that both ends switch in conjunction. In uni-directional schemes the traffic in one direction can be selected from the “worker” and in the other direction from the “protection” capacity.
- Force switch command. By issuing a force switch the user forces the traffic to either “worker” (force to worker) or to “protection” (force to protection).
- Manual switch command. By issuing a manual switch the user requests the traffic to either “worker” (manual to worker) or to “protection” (manual to protection) side. The request is only honored if the designated capacity is not affected by “Signal Fail” or “Signal Degrade” defects.
- Lockout of Protection command. By issuing a Lockout of Protection command all access to the protection side is denied.
- Clear command. Clears all pending requests.

The following interfaces support 1+1 MSP

- STM-0 tributary interfaces support 1+1 MSP according to the G.841/Annex B protocol. This protocol version supports only non-revertive operation with bi-directional control.
- STM-1 and STM-4 optical tributary interfaces support 1+1 MSP all three types of MSP protocol:
  - According to G.841/Annex B supporting only non-revertive operation with bi-directional control.
  - According to G.841/Clause 7 supporting both revertive and non-revertive operation and both uni-directional and bi-directional control.

- According to ANSI T1.105 and Telcordia GR-253-CORE supporting only non-revertive operation with uni-directional control.

- STM-16 aggregate interfaces support 1+1 MSP according to G.841/Clause 7, with both revertive and non-revertive operation and both uni-directional and bi-directional control.

Sub-network connection protection (SNCP)

The WaveStar® ADM 16/1 supports Sub-Network Connection (SNC) protection, also known as path protection, according to ITU-T Recommendation G.841/Clause 8. It is available at the VC-12, VC-3 and VC-4 level. SNC protection is a simple 1+1 protection scheme which only supports uni-directional operation. The big advantage over the MS-SPRing and MSP schemes is that the protection can be applied over the whole VC-n path from source to sink termination point, but also on one or multiple parts of the end-to-end path. In this way SNC protection is very flexible.

The WaveStar® ADM 16/1 supports VC-4 SNC protection between any pair of VC-4 in the higher-order matrix, located on the cross-connect unit. Protection can be set up between to VC-4s from tributary interfaces or between two VC-4s from aggregate interfaces or between a VC-4 from a tributary interface and a VC-4 from an aggregate interface. The WaveStar® ADM 16/1 supports VC-3 and VC-12 SNC protection between any pair of VC-3s or VC-12s, irrespective of their source/destination in the lower-order matrix, also located on the cross-connect unit. The protection switch time for SNC protection is 50 ms.

The SNC protection scheme supported in the WaveStar® ADM 16/1 is of the non-intrusively monitored type or SNC/N. This variety not only protects against defects in the server layer (as Inherently Monitored SNC or SNC/I does) but in addition also against defects in the VC-n layer itself. So SNC/N protected VC-4s are protected against AIS or LOP at the AU-4 level (server layer defects) and against misconnections (trace identifier mismatch or VC-4 dTIM) or disconnections (unequipped signal or VC-4 dUNEQ) or signal degradations (VC-4 dDEG) in the VC-4 itself. Likewise, SNC/N protected VC-3s and VC-12s are protected against TU3/12-AIS and TU3/12-LOP (server layer defects) and VC-3/12 dTIM, dUNEQ and dDEG.

Optionally for each SNC process, the trace identifier mismatch detection can be disabled. This feature allows interworking with equipment that transmits an unknown trace identifier or which uses a different format for it. The WaveStar® ADM 16/1 supports the 15 byte API plus 1 byte CRC-7 format for its Trail Trace Identifiers (TTIs).

Within the SNC protection mechanism it is possible to protect the complete end-to-end VC-n connection, but also to protect one or more part of it. When the end-to-end connection is split in multiple parts (thus truly creating *sub*-network connections), each part can be individually protected by an SNCP scheme. The WaveStar® ADM 16/1 supports the cascading of two such SNCP sections within one network element. This can be applied e.g. in cases where the WaveStar® ADM 16/1 interconnects between a ring over its tributaries and another ring over its aggregates. The protection mechanism in both rings can be two cascaded SNCP schemes, thus separating the protection in both rings. This helps in fault localization, because failures in a ring lead to protection switches in that same ring.

The WaveStar® ADM 16/1 supports “hold-off” timers for SNC protection. For each SNC/N process the user can provision a timer between 0 and 10 seconds in 0.1 second increments, which defines how much time should elapse before a SNC switch is initiated. This mechanism can be applied if several protection schemes are nested. E.g. a VC-12 SNCP scheme is used on top of an MS-SPRing. Normally, the MS-SPRing reacts within 50 ms. By provisioning a 100 ms hold-off time on the VC-12 SNC protection, the MS-SPRing is given the opportunity to react to a failure first. This avoids multiple switches.

Dual node interworking with drop & continue

The MS-SPRing protection mechanism offers very efficient protection but since the protection span is limited to a single ring network, there is need for a mechanism to couple ring networks in a way that avoids single points of failure, to allow longer end-to-end protected paths. This mechanism is called Dual Node Interworking with Drop & Continue. The advantages of using this mechanism are:

- Protected interconnection between MS-SPRing rings possible, thus allowing longer end-to-end protected spans, without single point of failure on each ring interconnect.
- Possibility to interconnect the MS-SPRing scheme to the SNCP scheme, without introducing a single point of failure. This allows the user the flexibility to use the protection scheme of choice in each network part, while avoiding double protection.
- Independence of the protection mechanisms in different network parts, which results in protection switches relatively close to the failure, so in principle easier to fault-locate.
- A higher availability, compared to end-to-end SNCP protection schemes. Especially on very long connections, more protection against multiple failure is provided (as long as there is at most one failure per protected sub-network).

Dual Node Interworking with Drop and Continue is a mechanism described in ITU-T Recommendation G.842, and it is realized by connecting the two networks in question in two different locations in such a way that if one location fails completely, the traffic can still reach the other network via the second interconnection.

The WaveStar® ADM 16/1 supports two different DNI configurations:

1. Between two MS-SPRing rings. The ring interconnection consists in this case of four network elements. Two network elements in each ring which are pair wise connected (see figure 4.12)
2. Between an STM-16 MS-SPRing ring and a LO-SNC protected subnetwork. In this case the interconnect can be built with just two nodes, which are connected to the MS-SPRing via the aggregate interfaces and to the SNC protected network via the tributary interfaces (see figures 4.12 to 4.15).

The MS-SPRing part of the DNI scheme allows for each individual VC-4, the assignment of primary and secondary “add” and “drop” nodes. Dropped traffic is broadcasted to both primary and secondary outputs (“drop & continue”), while a selector in the primary node selects whether the added traffic from the primary of from the secondary node is

forwarded onto the MS-SPRing. This selector is usually called a “service selector” is non-revertive and operates according to the VC-4 SNC/N criteria.

The following features are supported:

- The traffic between the primary and secondary node in the MS-SPRing can be transported over “worker” capacity or over “protection” capacity, called “continue over worker” and “continue over protection” respectively. The latter option saves bandwidth but leads to slightly lower availability and precludes “extra traffic” to make use of that same capacity.
- Both VC-4 and VC-4-4c payloads can be handled.
- Primary and Secondary nodes can be selected for each VC-4 transported over the MS-SPRing, both at the entry and at the exit side. These nodes need not be adjacent.

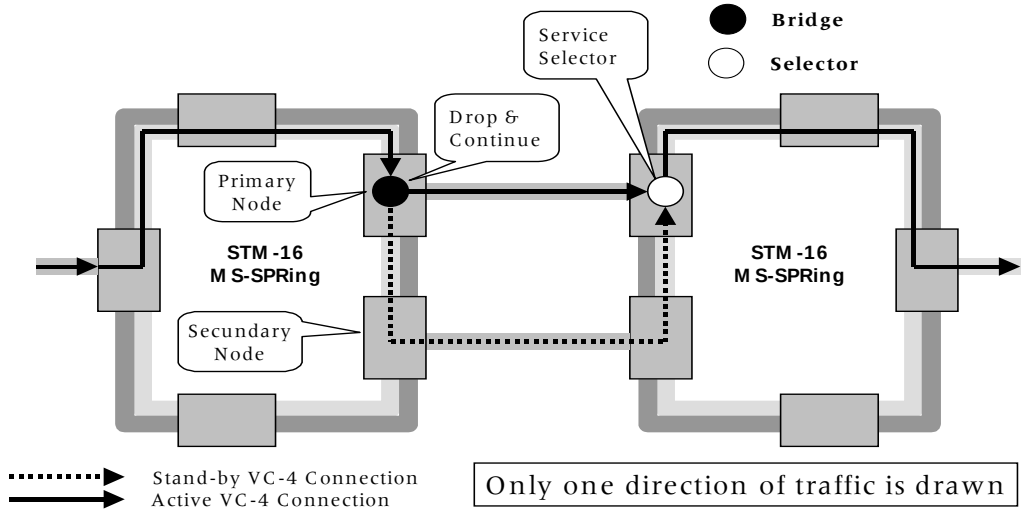


Figure 4-12. DNI between two MS-SPRing rings.

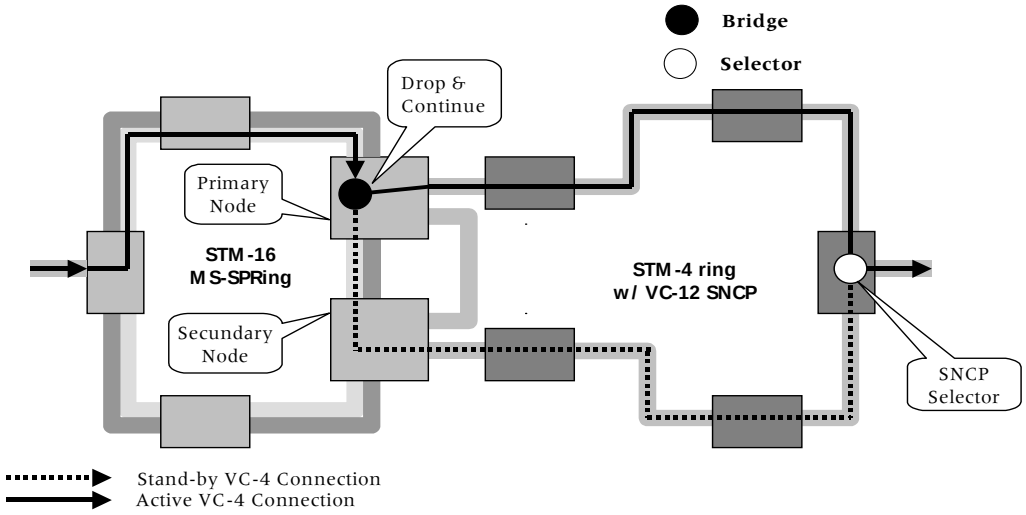


Figure 4-13. DNI with drop & continue between MS-SPRing and LO-SNCP, two node configuration.**Traffic from MS-SPRing to LO-SNCP.**

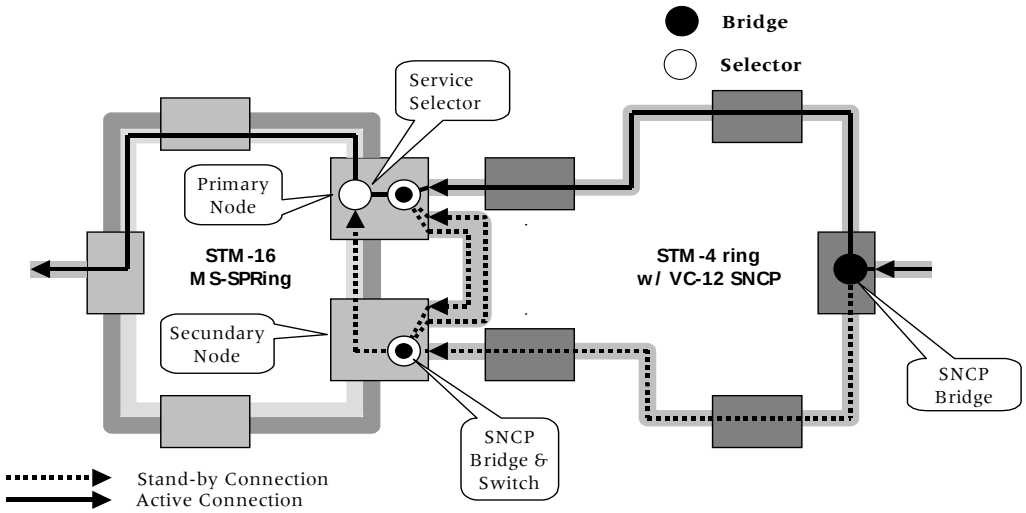


Figure 4-14. DNI with drop & continue between MS-SPRing and LO-SNCP, two node configuration.**Traffic from LO-SNCP to MS-SPRing.**

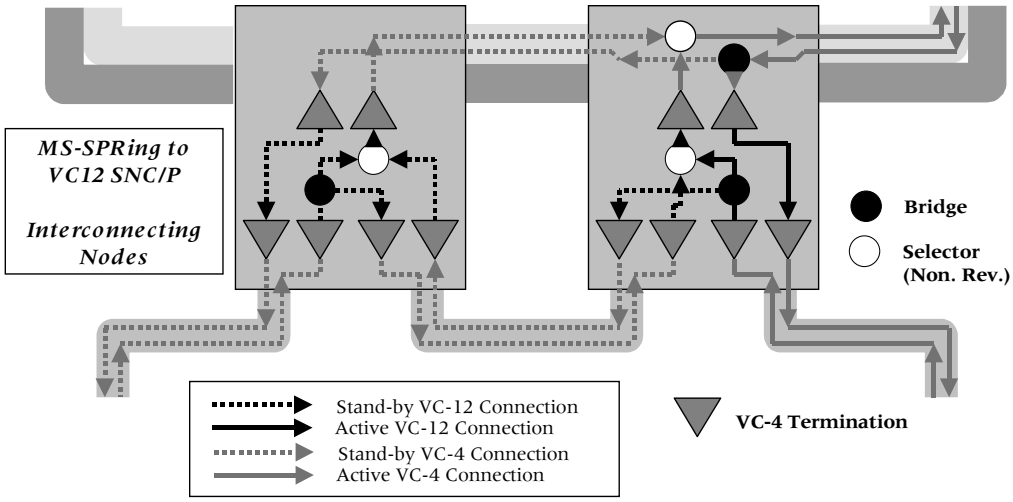


Figure 4-15. DNI with drop & continue between MS-SPRing and LO-SNCP, two node configuration. **Detailed view of interconnecting nodes.**

Operations Administration Maintenance and Provisioning

5

Overview

This chapter defines the “Maintenance Philosophy” outlining the various features available for monitoring and maintaining the WaveStar® ADM 16/1 Multiplexer and Transport System.

Operations

Element and Network Management aspects of WaveStar® ADM 16/1 are based on the SDH concepts as laid down in ITU-T recommendations, for instance G.784.

Local operations facilities are based on long-term experience and several commonly applied operations and alarms procedures.

The WaveStar® ADM 16/1 is additionally provided with advanced diagnostic features which can be used for equipment performance checks and detailed fault location.

Introduction

The WaveStar® ADM 16/1 maintenance procedures are built on two levels of system information and control. The first maintenance tier is provided by the:

- User panel
- Circuit pack faceplate LEDs
- Operations Interfaces.

These features enable maintenance tasks (that is, circuit pack replacement) to be performed without an ITM-CIT (Craft Interface Terminal) or external test equipment. The second maintenance tier uses the ITM-CIT to retrieve detailed reports about alarms and status, and system configuration for local terminals.

User Panel

The User Panel of the WaveStar® ADM 16/1 is integrated in the faceplate of the System Controller (SC) circuit pack, as shown in Figure 5-1. Lightguides are used to make the alarm and status indicators on the SC visible with the front door of the subrack closed. The door must be opened to operate the buttons or make connection to the ITM-CIT connector. The user panel provides system-level information.

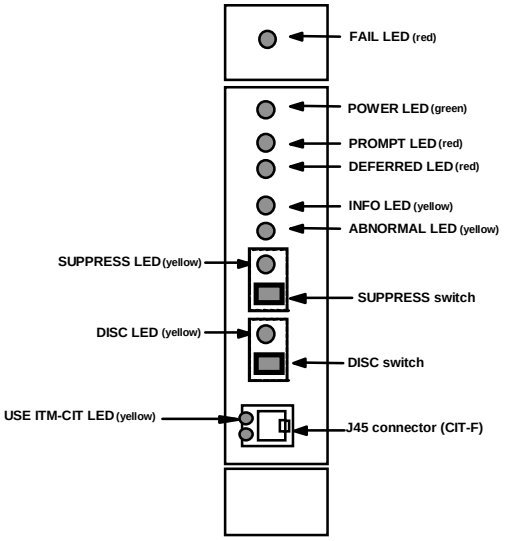


Figure 5-1. WaveStar® ADM 16/1 user panel: SC faceplate

User Panel LEDs and Connector

The User Panel LEDs show the following system information:

- FAIL

  A red FAIL LED is lit when at least one prompt or deferred maintenance alarm exists.

- POWER

  A green POWER LED indicates that voltage is present on at least one of the -48V secondary power-distribution feeds inside the system.

- The active alarm level is shown by LEDs for
  - PROMPT alarms

    A red PROMPT LED indicates a transmission affecting malfunction.

  - DEFERRED alarms

    A red DEFERRED LED indicates a no transmission affecting malfunction

  - INFO alarms

A yellow INFO LED indicates a failure that is not located within the terminal.

If only the INFO indicator is lit, no immediate maintenance action is required.

The alarm severities (CRITICAL, PROMPT, DEFERRED and INFO) of the fault messages, are user provisionable.

- ABNORMAL

  A yellow ABNORMAL LED indicates a the existence of abnormal conditions initiated in the Network Element, for example: a protection lock out, forced switch, manual switch, protection line in use, alarms disconnected, installation self-test failed.

- SUPPRESS

  A yellow SUPPRESS LED indicates that the SUPPRESS key has been activated while an active office alarm condition exists.

- DISCONNECT

  A yellow DISC LED indicates that the DISC(onnect) key has been activated, which means that office alarms are disconnected.

- USE CIT

  A yellow USE ITM-CIT LED indicates when the ITM-CIT must be used to obtain more detailed information about system status. This LED is part of the ITM-CIT connector.

User panel Controls and Connector

Two manual controls (switches) and one connector are mounted on the SC faceplate. The following functions can be distinguished:

- SUPPRESS SWITCH

  An alarm that is shown on the user panel can be suppressed by pressing the SUPPRESS SWITCH push button, consequently the SUPPRESS LED lights up. If another alarm of the same class occurs, it can now be noticed.

- DISC SWITCH

  The DISC SWITCH push button inhibits the activation of office alarms when pressed, consequently the DISC LED lights up.

- ITM-CIT connector

  The ITM-CIT connector is a RJ-45 connector. It is also called the F-interface, and interfaces with the local element management system.

Circuit Pack Faceplate LEDs

To supplement the user panel's system-level view, each circuit pack has a red FAIL LED on its faceplate (at the top of the faceplate). During normal fault-free operation, the LED is not lit. A continuously lit FAIL LED means the WaveStar® ADM 16/1 has isolated a failure to this circuit pack or when the circuit pack has been inserted in a slot which cannot support or is not configured to support this type of pack. A 1 Hz flashing FAIL LED shows the following:

- A flashing FAIL LED on a interface circuit pack indicates that an incoming signal to that circuit pack has failed
- A flashing FAIL RED LED on a Power and Timing (PT) circuit pack indicates an external timing reference failure.
- A flashing FAIL LED on the SC indicates loss of communication with the Navis™ Optical Management Solution.

It is user provisionable if FAIL LEDs flash or are continuously off in the case of an alarm as indicated above.

The PT circuit pack has a second, green, LED. This LED lights up when the external supply voltage is present.

Note: paddle boards have no indicators.

Operations Interfaces

The WaveStar® ADM 16/1 system supports office (station) alarms, user-settable miscellaneous discretes and a message-based operations system interface.

Office (Station) Alarm Interface

The office-alarms interface is a set of discrete relays (floating contacts) that control office audible and visible alarms. The relays are located on the system controller (SC) circuit pack. The relays are activated when a PROMPT or DEFERRED Maintenance Alarm situation exists in the system to activate: End-Of-Suite, Bay-top, Station alarms and Miscellaneous maintenance information. They are made available via a connector on the interconnection box (ICB); both disconnectable and non-disconnectable outputs are available. The miscellaneous conditions consist of suppressed alarms present, disconnect function activated and main--controller removed.

Miscellaneous Discretes

The miscellaneous discrete interface allows an operations system to control and monitor equipment co-located with the WaveStar® ADM 16/1 system through a series of input (MDIs) and output (MDOs) contact closures. Eight miscellaneous discrete inputs can monitor such conditions as open doors, high temperature or high humidity, and four miscellaneous discrete control outputs can control equipment such as fans and generators. The statuses of the miscellaneous discrete environmental inputs are reported to the

WaveStar® ITM-SC network element management system. It is possible to activate these miscellaneous discrete control outputs from the WaveStar® ITM-SC network element management system when the system reports an alarm condition. Miscellaneous discretes are provided to the user through a connector at the interconnection box.

MDI/MDO Management

It is possible for the user to control all MDOs of all WaveStar® ADM 16/1s under a single WaveStar® ITM-SC by means of a scripting facility. These scripts can be edited, activated and de-activated during runtime. The scripts are sufficiently flexible to allow activation or de-activation of certain MDOs based on combinations of certain alarms or MDI statuses on those network elements. Strings can be assigned to MDOs and their status is visible to the user.

Network Management Interfaces

- Q-LAN interfaces

  The Q-LAN interfaces enable network-oriented communication between the WaveStar® ADM 16/1 and the WaveStar® ITM-SC and Navis™ Optical NMS. This is the standardized interface to Navis™ Optical Management Solution.

  Two physical interfaces for Q-LAN are available and available on the interconnection box:

  - 10 Base-T: Twisted Pair Ethernet, (10 Mbit/s)
  - 10 Base-2: Thin Ethernet or Cheapernet, (10 Mbit/s).

  It is not possible to use both interfaces simultaneously.

- CIT-F (Craft Interface Terminal) Interfaces

  Three logical connection points for a CIT are available: 3 x CIT-F.

  Three connection points for local use are available: one on the User Panel (faceplate SC), which can be used by a crafts person working in front of the equipment. The second CIT-F interface is available on the system's interconnection box and can be used by a crafts person working with the EMC boundary closed. The last one is present on the rear side of the system.

  Electrical characteristics of both CIT ports comply with V.10.

Additional Operational Features

Loop-backs

Within the WaveStar® ADM 16/1 loop-backs are possible at VC-n level or AU-4 level. The VC-n level can be used for far-end / near-end loop-backs and AU-4 for a loop-back within the higher order cross-connect. The 2 Mbit/s, STM-0o, STM-1o and STM-4 have

both far-end and near-end loop-back possibilities. The STM-1e will be loop-backed via the higher order cross-connect.

Far-end refers to looping back the signal coming from the cross-connect back to the cross-connect via a tributary. Near-end refers to directly looping back incoming signals as outgoing signals.

Loop-backs are also allowed when the optical STM-N interfaces are being provisioned as 1+1 MSP protected.

NOTE:
Due to device problems on the units as listed below (and also newer versions) the far-end loopback on STM-1 and STM-4o is not working anymore when operated in SDH (AU-4) mode. In this case traffic needs to be loop-backed via the cross-connect. When operated in AU-3 conversion mode these far-end loopbacks are working fine. A software change is available in order to work around the problems via a VC lopback on the CC unit.

Unit type	Itemcode	Comcode	Remarks
SI-L4.2/1+6dB B	LJB405B	108681677	Not orderable anymore
SI-L4.2/1	LJB405C	108862509	
SI-S4.1/1B	LJB416B	108442005	
SPIA-1E4/4B	LJB431B	108681651	
	LJB431T	108988312	
SIA-1/4B	LJB439B	108884610	
	LJB439T	108988338	

User channels

The STM-1, STM-4 and STM-16 section overhead and the VC-3/VC-4 path overhead contain several bytes, for instance E and F bytes, which can be used to provide 64 kbit/s operations channels.

The WaveStar® ADM 16/1 provides for a maximum of six transparent 64 kbit/s channels selected from the following overhead bytes:

- E1 and E2 bytes: The use of which is mainly referred to as: engineering order wire channels
- F1 and F2 bytes: The use of which is mainly referred to as: user channels
- MS-NU and RS-NU bytes: The use of which is mainly referred to as: National Use bytes.

The selected six overhead byte channels are fed via the System Controller to the integrated interconnection box and are available via: 4 x G.703 co-directional interfaces and 2 x V.11 contra-directional interfaces.

See chapter 9 for more details on the overhead bytes.

Remote login/single ended operations/NSAP addresses (programmable)

The interfaces for the CIT-F (F-interface) provide the facility to log onto the local WaveStar® ADM 16/1. The WaveStar® ITM-SC can perform these control and provisioning tasks remotely.

The NSAP address is programmable to enable compatibility with the NSAP addresses of existing products like ISM, SLM, PHASE, etc. This will allow DCC interworking with other kinds of equipment.

Data communications channel

This network operations capability uses the SDH section (MSOH and RSOH) data communication channel (DCC) bytes. Management interface dialogs and operations interface messages travel in these DCC bytes on each STM-1 (optical and electrical) interface. Other optical signals like STM-16, STM-4 and STM-0 are also supporting the DCC channel.

Severity setting for alarms on each termination point instance

Since different clients pay for different quality of service (QoS), the priority and time to repair can differ for different paths. By setting a higher severity for the alarms on paths that require a high QoS, than for the paths that require a low QoS, the promised QoS can be met better. In the subsection **Performance Monitoring** the concept of quality of service is explained in more detail.

Support of a multiplex section trace identifier (J0 byte)

The user can provide a multiplex section trace identifier on all STM-N (N=1,4,16) outputs of the WaveStar® ADM 16/1 via the WaveStar® ITM-SC or ITM-CIT. In the receive direction an expected value for this trace identifier can be provided. In case of a mismatch a TIM (trace identifier mismatch) alarm is generated an consequent actions are invoked. The TIM detection mechanism can be disabled per interface.

Administration

Version Recognition

The system provides automatic version recognition of all hardware and software installed on the system. The system can report the type, version and serial number of the circuit pack installed in each slot. Each circuit pack identification code is stored on the circuit pack itself and is accessible by the system controller.

User login security

The ITM-SC network element management system provides security protection against unauthorized access to the network element functions (for example provisioning). This feature controls access to the system on an individual user basis including:

- Login ID and password assignment

  This requires the user to enter a valid Login ID and password to access the system.

- User authorization levels

  Provides three levels of access on a per session basis:

  - **Administrator**

    The Administrator is authorized to perform WaveStar® ITM-SC system control activities. This includes starting and stopping management of the transmission network. Only this user can administer other users of the WaveStar® ITM-SC application. In addition, backups can be created or restored by this user.

  - **Operator**

    Authorized for all retrieval and operate commands that are not service affected and does not imply system configuration changes.

  - **Supervisor**

    Authorized for all retrieval, provisioning and operate commands, as well service and not service affected handling, with the exception of provisioning security data and software downloads.

Software Upgrades

Upgrading and reconfiguring the WaveStar® ADM 16/1 to support new services or to incorporate feature enhancements can easily be implemented by downloading a new software generic via the appropriate (F) Operations interface.

Normally, however, depending on the actual situation, downloading and replacing software generics do not cause service interruption.

Performance Monitoring

Performance monitoring can be used for, broadly speaking, two applications. The first application is for maintenance applications, the second application is for "Quality of Service (QoS)" monitoring. The WaveStar® ADM 16/1 performance monitoring features are based upon ITU-T Recommendations G.784, G.826, G.827, G.829, M.2101.1, M.2110 and M.2120. All definitions of maintenance parameters are according to G.784 and G.826.

Maintenance Applications

The maintenance applications are based on ITU-T Recommendations M.2101.1, M.2110 and M.2120 and are used for "bringing into rervice (BIS)" and other initial testing procedures and localization/monitoring of under-performing parts of an end-to-end path. To support these applications the WaveStar® ADM 16/1 provides for each performance monitoring process, the current 15 minute interval and current 24 hour interval counts of the BBE (background block errors), ES (errored seconds), SES (severely errored seconds) and UAS (unavailable seconds). In addition the recent history of these parameters remains stored in the network element: the 16 most recent complete 15 minute counts and the 1 most recent complete 24 hour count.

For all current interval counters, thresholds can be set that control the forwarding of threshold report (TR) and reset threshold report (RTR) information to the management system. A TR is generated at the moment that the actual count in a current register crosses the "set" threshold level for the first time since the last RTR. An RTR is generated at the end of the first interval in which the actual count remains below the "clear" threshold. So the TRs and RTRs are generated alternatingly. In the period between a TR and an RTR the monitored part of the path is considered degraded, while the period between a RTR and a TR it is considered normal. "set" and "clear" thresholds can be assigned by the user via the ITM-CIT or the WaveStar® ITM-SC.

In addition to the parameters above, also the 6 most recent UAPs (unavailable periods) are logged in the system. Each UAP is represented by two timestamps. The first indicates the time of entering "unavailable time" and the second indicates the subsequent entering of "available time".

For maintenance applications the WaveStar® ADM 16/1 supports the counting, threshold monitoring and logging of all the parameters mentioned above for the incoming traffic direction (or "uni-directional near-end" performance monitoring). Possible monitoring points are VC-12, VC-3 and VC-4 trail terminations points (TTPs) as well as on MS-0, MS-1, MS-4, MS-16 and RS-16 termination points as well as VC-4 and VC-4-4c transit points or connection termination points (CTPs). In R4.1 also VC-12 and VC-3 CTPs is supported. Note that the uni-directional near-end performance monitoring provides the performance of the incoming signal between the signal trail source and the monitoring point.

The BBE, ES, SES, UAS and UAT parameters are derived from the errors in the incoming signal, based on the B1, B2, B3 or V5 (bit 1,2) parity information which is part of the RSOH, MSOH or VC-POH. Periods of unavailable time are, additionally, based on local defacts or defects in the incoming signal. For the duration of a period of unavailable time the BBE, ES and SES counters are inhibited.

Quality of service application

The quality of service (QoS) applications are based on ITU-T Recommendations G.826 and G.827. In contrast with the maintenance application, the QoS application requires a performance assessment of the bi-directional path over longer periods.

To support the QoS application in the network element, the WaveStar® ADM 16/1 provides the logging of the current and most recent 24 hour periods of the UAP, UAP-count (number of unavailable periods) and UAS for the bi-directional connection, whereby the bi-directional connection is considered unavailable as soon as one of the direction is unavailable. In addition, for each monitoring point the BBE, ES and SES counts are reported for both directions individually. So there are nine parameters altogether per bi-directional monitoring point. Note that all six BBE, ES and SES counters are inhibited as soon as the bi-directional connection is unavailable. For this reason the bi-directional counts may differ from the uni-directional counts, even if they are concerning the same path and the same monitoring interval.

Bi-directional performance monitoring comes in two flavours: In “end-points” or TTPs or in “mid-points” or CTPs. The following monitoring points in the WaveStar® ADM 16/1 support bi-directional PM: VC-12, VC-3 and VC-4 TTPs, VC-4 and VC-4-4c CTPs and in R4.1 also VC-12 and VC-3 CTPs.

Bi-directional performance reports in end-points are based on the near-end and far-end (REI, RDI) information received on the incoming signal. Bi-directional performance reports in midpoints are based on the far-end information contained in the incoming signal in both directions of transmission.

Number of Performance Monitors

The WaveStar® ADM 16/1 can support 250 monitoring points simultaneously. The new SC2 system controller can even support 600 monitoring points simultaneously with Ruby Release and up to 1200 monitoring points with the Pearl Release. These can be randomly selected from all the possible TTPs and CTPs indicated above, counting the “uni-directional near-end” and “bi-directional” applications as different. Once a performance monitoring point is activated the full set of performance parameters is supported. Activating or de-activating a performance monitoring process can be performed from the ITM-CIT or WaveStar® ITM-SC.

Note: On WaveStar® ADM 16/1, 600 or 1200 monitoring points can only be used in combination with Ruby controller hardware (LJB457B) and Ruby Cross-connect-64/32 (LJB434).

Performance Monitoring for LAN ports

On the VC3/VC12 termination points that are connected to a WAN port, the "normal" performance monitoring can be activated. The same counters that apply for VC3/ VC12TPs on any other port also apply to the VC3/VC12 TP’s on a WAN port.

Apart from this standard SDH PM, a limited amount of counters that are dedicated to LAN/WAN ports are defined. Activation of these counters can be established by setting

the LAN port mode to monitored, selecting a LAN port or WAN port as active PM point, and setting the PM point type to LAN or WAN.

The supported dedicated parameters are:

- CbS (total number of bytes sent)
- CbR (total number of bytes received)
- pDe (packets in error dropped)

Note that CbS and CbR are rather traffic monitoring counters than performance monitoring counters, as they give insight in the traffic load in all places in the network. pDe is a real performance monitoring counter as it gives an indication about the performance of the network. Only unidirectional PM is supported for these parameters. See Figure 5-2 for the location of the measurements. Note that because of the difference in units, bytes versus packets, the counters cannot be correlated with each other. Also the counter for dropped packets considers only packets dropped due to errors, and does not include packets dropped due to congestion.

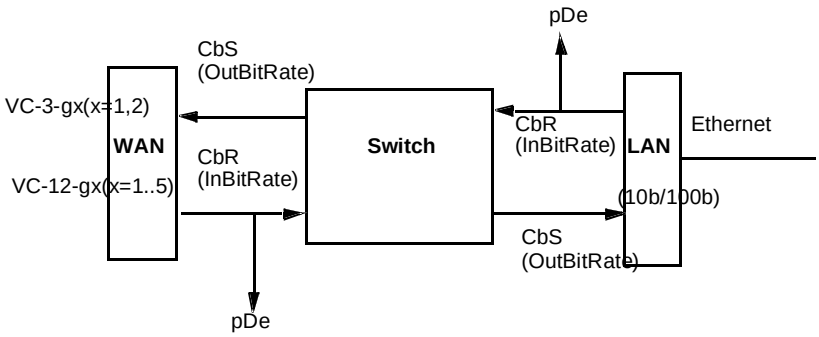


Figure 5-2. Performance Monitoring Counters

Performance Monitoring on LAN connections (Gigabit Ethernet ports)

It is possible to monitor byte and packet related performance parameters on any external Ethernet port and any internal port linked with VC-3/4-Xv channels. The following counters are supported for each port :

· Outgoing number of bytes

· Incoming number of bytes

· Number of incoming packets dropped

Accumulation of counts in 15 min and 24 hour bins can be selected per port. Recent bins are stored : 16 recent 15 min bins and 1 recent 24 hours bin. Thresholding (TR/RTR) on counts of dropped incoming packets can be enabled and configured per port.

Maintenance

Maintenance signaling

The system maintenance signals notify downstream equipment that a failure has been detected and alarmed by some upstream equipment, and notify upstream equipment to initiate trunk conditioning due to a failure detected downstream.

These alarm signals include alarm indication signals (AIS), far end receive failure (FERF) signals, and unequipped signals (UNEQ).

AIS detection on 2Mbit/s ports for asynchronous mapping

It is possible to monitor the CRC-4, E-bit and A-bit information in TS0 of any 2 Mbit/s in both directions for performance monitoring purposes for G.704 structured 2 Mbit/s tributaries.

Alarms and status reports

The system provides a report that lists all active alarm and status conditions. This report is made available to the Navis™ Optical Management Solution on demand. The identity of the condition is included in the report along with a time stamp indicating when the condition was detected. There is an option to display specified subsets of alarm conditions.

Element Management and remote operations interfaces

Before it can begin providing services, the WaveStar® ADM 16/1 requires a large amount of provisioning data.

This data will be loaded upon installation in non-volatile memories but needs a reliable backup to support repair and maintenance procedures. It is therefore assumed that the equipment is connected to a back-up database either via a local port or via the embedded operations channels.

The WaveStar® ADM 16/1 can be connected to a co-located WaveStar® ITM-SC Management System via the Q-LAN. At station level and besides local or remote Navis™ Optical Management Solution facilities, a craft interface terminal (ITM-CIT) can be used to carry out local management functions.

This application is often referred to as “Centralized Alarming and Remote Login”

Fault Detection, Isolation and Reporting

When a fault is detected, the WaveStar® ADM 16/1 employs automatic diagnostic to isolate the failed circuit pack or signal. Failures are reported to local maintenance personnel and operations systems so that repair decisions can be made. If desired, operations system personnel and local maintenance personnel can use the ITM-CIT to gain more detailed information on the fault condition.

A maintenance history report containing past alarms, status, protection switching, and craft or management events is provided, and made available to the Navis™ Optical Management Solution on demand. This summary contains time stamp indicating when each condition was detected and cleared, or when a command was entered.

The WaveStar® ADM 16/1 system also automatically and autonomously reports all detected alarm and status conditions through the office alarm relays, user panel, equipment LEDs, and message based operations systems.

Reports

Active Alarms and Status

The WaveStar® ADM 16/1 provides a report showing all the active alarm and status conditions. The local alarms and status report are displayed automatically on the local ITM-CIT immediately after log in or directly on the network element management system. The report shows the following alarm levels:

- PROMPT
- DEFERRED
- INFO
- NO REPORT.

The source address description of the alarm condition (for example controller failure, high-speed signal failure) is included in the report along with the date and time detected. The report also shows whether the alarm condition affects operations. The option to display specified subsets of alarms conditions by severity is also provided.

Reporting of Analog Parameters

Upon user request, the WaveStar® ITM-SC and ITM-CIT can report the values of the laser bias current and optical transmitted power (derived from backface current) of any STM-16 unit in the system. In addition, the value of the optical received power is reported, provided the STM-16 port unit in question actually supports this parameter in its hardware.

State

An on-demand report displays the equipment and the equipment status.

Equipment report contains:

- equipment
- location
- circuit pack type
- version
- slot status, (the slot status can be auto or equipped).

Equipment status contains:

- equipment
- location
- circuit pack type
- port status (if applicable)
- service status (if applicable).

Version/equipment List

The version/equipment list report is an on-demand report that lists the circuit packs version and the software generic (if applicable). This report also lists all of the circuit packs that are present.

Synchronization Report

The synchronization report is an on-demand report that lists the status of the system synchronization. This report lists all the clock parameters that can be interrogated.

Provisioning

The system supports many system applications by its provisioning features.

Provisioning parameters are set by software control. These parameters vary from one installation to the next, and a wide range of options or in-service changes can be provisioned locally or remotely with the aid of an ITM-CIT or WaveStar® ITM-SC.

Default provisioning

Installation provisioning is minimized with carefully chosen default values/parameters defined and maintained in the System Controller, and a simple command can be given to restore all default values. All provisioning data is stored in non-volatile memory to prevent data loss during power failures.

Automatic provisioning on replacement

Replacement of a faulty circuit pack is simplified by the automatic provisioning of the original values. The system controller maintains a provisioning map of the entire subrack so when a transmission or synchronization circuit pack is replaced, the system controller automatically downloads values to the new circuit pack and initiates testing of the new circuit pack. If the system controller itself is replaced, provisioning data from a back-up database mounted in the WaveStar® ITM-SC, is automatically downloaded to the new System Controller's non-volatile memory assumed it is empty.

If the controller database is not empty but valid, the choice is offered to download or upload.

Provisioning reports

The provisioning report, which is made available to the WaveStar® ITM-SC on demand, contains the current values of all electronically provisionable parameters.

Cross-Product Interworking

6

Overview

This chapter contains a brief description of the Lucent Technologies SDH systems that interwork with the WaveStar® ADM 16/1 in today's telecommunications networks. The application of the WaveStar® ADM 16/1 is briefly described in Chapter 3, Applications.

For more detailed information, reference is made to the Application and Planning Guide of the system concerned.

Lucent Technologies SDH Product Family

Lucent Technologies SDH Product family is well suited for PDH and SDH network applications serving line rates from 1.5 Mbit/s to 400 Gbit/s. In addition, this product line also accommodates asynchronous transfer mode (ATM). Lucent Technologies designed the following members of the SDH product family which can interwork with the WaveStar® ADM 16/1:

- Metropolis™ EON (formerly know as WaveStar® OLS 80G)
- WaveStar® OLS 1.6T (formerly know as OLS 400 G)
- WaveStar® BWM
- WaveStar® DACS 4/4/1
- WaveStar® ADM 4/1 SDH multiplex system
- WaveStar® TM 1 and AM 1
- WaveStar® AM 1 Plus
- WaveStar® ADM16/1 Compact
- WaveStar® TDM 10G (SDH)
- SDH Radio Systems
- WaveStar® EOW
- WaveStar® ITM-SC Controller, an Element Management system for the SDH Multiplexer and Transport System
- Navis™ Optical NMS, a Network Management system for transport networks.

From a network point of view, SDH is the answer to the rapidly changing demand for services on the one hand, and on the other the increasing cost of implementing these services in switching equipment. The latter means that the switching equipment has to provide for larger and larger areas to keep cost per line at an economical level. This causes an increase in the deployment of transmission systems because the average distance between subscribers and the central exchange (and also the distance between exchanges) increases. The cost penalty for extra transmission equipment was relatively low thanks to new developments in transmission technology (e.g. optical fiber).

The existing (plesiochronous digital hierarchy - PDH) transmission network is structured with a fixed multiplex architecture (2/8, 8/34, 34/140 Mbit/s). Digital distribution frames are installed between the multiplex equipment where the signal cabling is connected. The routing of some of the data streams is established with these connections. The other streams are demultiplexed to 2 Mbit/s and connected to the exchange. Making changes in such a transmission network requires manual action and accurate administration. So flexibility is not optimal and operating costs increase when the demand is changing continuously.

Network systems

Metropolis™ EON (formerly know as WaveStar® OLS 80G)

Because the demand from customers for extra capacity is growing every day, there is a limiting factor for most network operators: the number of available fibers!

By using the Metropolis™ EON system together with the WaveStar® ADM 16/1 system, it is possible to enhance the span capacity by a factor of 32. Distances of up to 640 km can be bridged by using the Metropolis™ EON system together with the WaveStar® ADM 16/1.

WaveStar® OLS 1.6T DWDM system(formerly know as WaveStar® OLS 400G)

The WaveStar® OLS 1.6T fully-open architecture enables carriers to simultaneously mix and match for the first time combinations of 2.5 Gbit/s (STM-16) and 10 Gbit/s (STM-64) SDH channels over one fiber. Adding to its versatility the WaveStar® OLS 1.6T is the first system to support a combination off 2.5 Gbit/s (STM-16) and 10 Gbit/s (STM-64) equipment from a variety of vendors.

The WaveStar® OLS 1.6T is designed as a single broadband platform to be cost effective, even when used in small, start-up configurations. The WaveStar® OLS 1.6T gives any service provider the flexibility to upgrade up to 80 channels by adding optical DWDM circuit packs two channels at a time, rather than in larger increments. With advanced operational features such as optical add/drop and gain control built into the Lucent WaveStar system, service providers can automatically tailor channel configurations to match bandwidth needs. The WaveStar® OLS 1.6T is available with a network management system for integrated administration of the optical and SDH layers.

See Figure 6-1

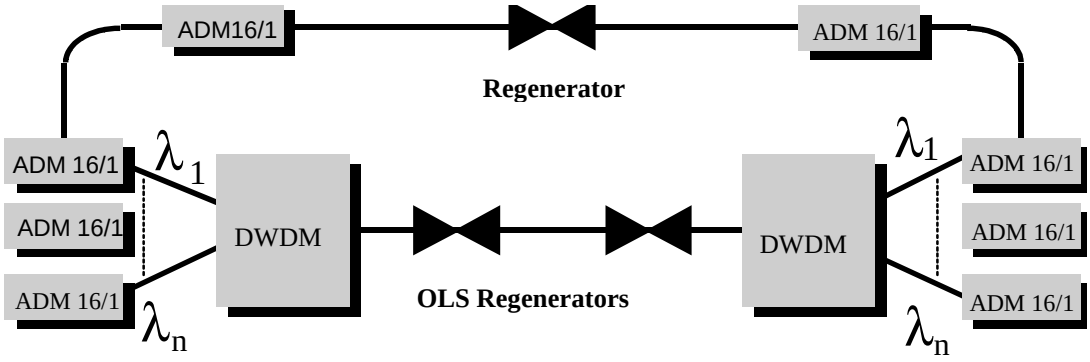


Figure 6-1. WaveStar® ADM 16/1 Interworking with WaveStar® OLS 1.6T (n=80)

WaveStar® BWM

WaveStar® BandWidth Manager (BWM) is a modular networking system integrating a broadband cross-connect fabric with access and interoffice transport facilities. This network element consolidation provides fewer points of failure and fewer elements to manage. The scalable platform easily responds to demands for network growth, future-proofing your network. WaveStar® BWM integrates traditionally separate SONET and SDH linear and ring interfaces found in TDM stand-alone add/drop multiplexers, and a broadband cross-connect fabric, into a single network element, greatly simplifying OAM&P functions. Features:

- Operational savings
- Increased reliability
- Integrated optical line systems
- Future proof - scalable networks
- Substantial first equipment cost savings

WaveStar® DACS 4/4/1

The WaveStar® DACS 4/4/1 is the latest cross-connect system from Lucent Technologies. It is a large-capacity SDH 4/4/3/3/1 cross-connect system. It can operate in any of the following modes:

- Broadband (4/4) mode
- Wideband (4/3/1) mode
- Broadband/Wideband (4/4/3/1) mode.

In all three modes, the WaveStar® DACS 4/4/1 has an maximum capacity of 512 STM-1 equivalents. Furthermore, Lucent's proven multivendor world-class network manager, Navis™ Optical NMS, integrates WaveStar® DACS 4/4/1 into Lucent's complete SDH network offering.

Based on Lucent's experience with large SDH networks, the WaveStar® DACS 4/4/1 provides the following benefits:

- Large capacity cross-connect that is cost effective in small and large configurations
- Highly reliable cross-connect in which all service affecting components are either triple or double protected against equipment failure
- Broadband (4/4) restoration vehicle that increases broadband network reliability when combined with the Navis™ Optical NMS network manager. When operating in 4/4 mode the WaveStar® DACS 4/4/1 provides for system expansion to 512 STM-1 equivalents. This fully EMC and ESD-compliant product cross-connects AU-4s and AU-3s with a maximum transit delay of 15 microseconds.
- Wideband (4/1) restoration vehicle that increases wide band network reliability when combined with the Navis™ Optical NMS network manager. When operating in 4/1 mode, the WaveStar® DACS 4/4/1 provides the same basic feature set as the

former DACS VI and provides for system expansion to 512 STM-1 equivalents. However, WaveStar® DACS 4/4/1 is primarily designed for SDH to make it more suitable as a network restoration and grooming vehicle. The WaveStar® DACS 4/4/1 and DACS VI can be used in the same network, and both systems can be managed by the same network manager, Navis™ Optical NMS.

- Wideband grooming capability that allows the customer to improve network efficiency by optimizing bandwidth usage.
- 4/4/1 cross-connect that provides fast provisioning of wide band and broadband services as well as other network provisioning. WaveStar® DACS 4/4/1 is an excellent choice for applications in the trunk/junction part of the network. When operating in 4/4/1 mode, the Navis™ Optical NMS.
  DACS 4/4/ 1 combines the capabilities of a 4/4 cross-connect and a 4/1 cross-connect. Having the 4/4/1 functionality contained in a single cost-effective and flexible cross-connect not only results in lower equipment costs but also improves network manageability, especially when used in combination with Navis™ Optical NMS.

When connected to Lucent Technologies next generation WaveStar®
DACS 4/4/1, the WaveStar® ADM 16/1 can function as a vast hub multiplexer.

WaveStar® DACS 4/4/1 and WaveStar® ADM 16/1 can be interconnected via the following interfaces:

- STM-1 electrical
- STM-1 optical
- STM-4 optical
- STM-16 optical

STM-1 electrical interfaces can be with MSP1+1 protection or with 1:N (N<=8) equipment protection. The optical interfaces support both MSP1+1 as well as VC-12/3/4 SNC/N and SNC/I protection.

Today, the WaveStar® DACS 4/4/1 can cross-connect fully non-blocking a maximum of 512 x STM-1s. Cross-connecting at VC-4, VC-3, VC-2 and VC-12 level is supported (4/4/3/2/1 DXC). The WaveStar® DACS 4/4/1 distinguishes itself from other vendors DXC systems because of the very short AU-4 transit delay of approximately 15 microseconds. Like the WaveStar® ADM 16/1, the system is managed by Navis™ Optical NMS.

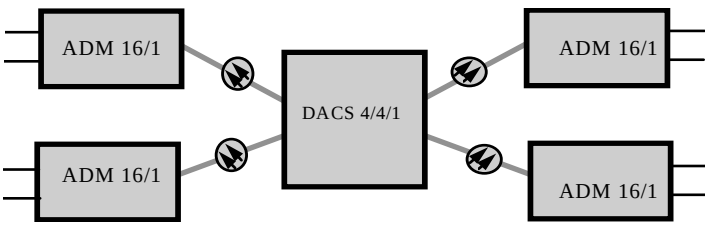


Figure 6-2. WaveStar® ADM 16/1 interworking with WaveStar® DACS 4/4/1

WaveStar® ADM 4/1

The WaveStar® ADM 4/1 system has as the main application to give access to an SDH network. It can work in both synchronous and asynchronous environments. Further, it contains an advanced pointer processing feature to eliminate phase shifts so it can be used for wireless base stations that need to be in perfect synchronization with the master station. The system can be used as a terminal multiplexer / dual terminal multiplexer (126 x 2 Mbit/s) or as an add/ drop multiplexer for up to 63 x 2 Mbit/s or a Hub Multiplexer for up to 5 STM-1 interfaces. It can be used in a large variety of network types such as rings, stars and strings. It has advanced protection mechanisms such as card protection, MSP, path protection and SNCP. Synchronization could come from various sources such as from 2 Mbit/s tributary, STM-1 aggregate incoming signal, STM-1 tributary incoming signal or an external 2 MHz clock.

The WaveStar® ADM 4/1 consists of a shelf with 1 supervision slot and 6 flexible slots that can contain units with one or more of the following functionalities: 16 x 2 Mbit/s tributaries, 32 x 2 Mbit/s tributaries, 34 Mbit/s or 45 Mbit/s tributary, STM-1 optical or electrical line interface, STM-4 optical line interface, transfer for the add/ drop function. All boards have on-board power converters. In case of card protection, 2 Mbit/s switches are mounted on the connecting field of the shelf.

The WaveStar® ADM 4/1 is controlled by and managed by Lucent Technologies Navis™ Optical Management Solution for network and element level management.

WaveStar® AM 1 & TM 1

The WaveStar® TM 1 & AM 1 is a compact and cost-effective STM-1 multiplexer designed to be installed at the customer’s premises or street cabinets for fiber-to-the-business, fiber-to-the curb and fiber-to-the office applications. The WaveStar® AM 1 will support either add-drop or terminal multiplexer applications. Its’ space-efficient design allows for wall-mounting or rack mounting in non-environmentally controlled locations. The WaveStar® TM 1 & AM 1 supports additional options (16) 2 Mbit/s E1 ports or (2) 34 Mbit E3 ports. The WaveStar® TM 1 & AM 1 measures 430 x 200 x 280 mm (H x D x W) and provides for a wall-mounted or rack-mounted unit.

The WaveStar® AM 1 and TM 1 are controlled by and managed by Lucent Technologies Navis™ Optical Management Solution for network and element level management.

WaveStar® AM 1 Plus

The WaveStar® AM 1 Plus is a multiplexer and transport system that multiplexes a broad range of plesiochronous and data signals into 622 Mbit/s (STM-4) or 155 Mbit/s (STM-1) signals. The system can be used as an add/drop multiplexer or a terminal multiplexer. It provides built-in cross-connect facilities and can accept one extension board. The WaveStar® AM 1 Plus can be used in the access part of the network in Local Loop applications (Fiber To The Business) or for intra-office applications. It offers simultaneous usual PDH interfaces (for voice traffic) and data interfaces, providing a good solution for multimedia local loop applications for small or medium business subscribers.

The WaveStar® AM 1 Plus is controlled by and managed by Lucent Technologies Navis™ Optical Management Solution for network and element level management.

WaveStar® ADM 16/1 Compact

Based on the proven WaveStar® ADM 16/1 technology, the WaveStar® ADM 16/1 Compact is an affordable, compact and flexible designed STM-16 add/drop multiplexer. Inspite of its compact, economical design, it delivers the power of a high capacity multiplexer. It supports a wide range of SDH line and SDH, PDH and Ethernet tributary interface types (2, 34, 45,155, 622MBit/s and 2.5GBit/s and 10/100Base-T). The VC-4 cross connect function is fully non-blocking for STM-4 and STM-16 applications while the LO crossconnect has a capacity of 32 VC-4 equivalents.

The WaveStar® ADM 16/1 Compact is controlled by and managed by Lucent Technologies Navis™ Optical Management Solution for network and element level management.

WaveStar® TDM 10G (SDH)

The WaveStar® 10G Time Division Multiplexer (TDM) is a global platform design supporting both the SONET product version as well as the SDH product version. This Product Description applies to the SDH version only which is referred to as the WaveStar® TDM 10G (STM-64). For info on the SONET version please ask for the WaveStar® TDM 10G (OC-192) Product Description.

The WaveStar® TDM 10G (STM-64) supports high-capacity, self-healing transport by means of an SDH-standard STM-64 line rate signal in an SDH-standard 2-fiber MS-SPRing protected ring. The feature set in the first release provides commonality with existing SDH transport products as well as an advanced set of market-proven features. The feature set will grow continuously in future releases. For planning reasons, major future features will also be mentioned within this Product Description.

Key features of the WaveStar® TDM 10G (STM-64) include:

- STM-64 and STM-16 2-fiber MS-SPRing transmission
- STM-1 (el)/STM-1(o), STM-4 and STM-16 interfaces
- 1+1 Multiplex Section Protection (MSP) for optical tributary interfaces
- 100% (64 x STM-1) add/drop capability to/from the STM-64 aggregate interfaces using any combination of available tributary interfaces.
- Flexible, non-blocking VC-3, VC-4 , and VC-4-4c granularity cross-connections
- TL1 operations interface
- controlled by and managed by Lucent Technologies Navis™ Optical Management Solution for network and element level management and WaveStar® CIT.

SDH Radio systems

To enhance the applicability of SDH and to provide full flexibility in network design, the range of Lucent Technologies SDH products includes a family of SDH STM-1 digital radio systems.

Digital radio systems are the preferred solution for otherwise inaccessible areas due to terrain or right-of-way limitations, as well as for back-up configurations.

The SDH radio equipment is designed to operate in frequency bands with 30, 40 or 55 MHz channel spacing, as defined in the relevant ITU-R Recommendations. Each radio channel can carry one STM-1 signal that can be utilized in several ways.

The SDH radio equipment provides for transmission of multiple STM-1 signals, realized either as protected or as unprotected configurations. Mapping has been integrated for PDH applications, making a 140 Mbit/s PDH interface available.

Changeover between 140 Mbit/s PDH and 155 Mbit/s SDH is easily implemented by the simple setting of switches. The 155 Mbit/s can support the DCC channels for communicating with other equipment after radio transmission.

Supervisory system

The SDH Radio system can be provided with a Q adapter for connection to the Lucent Technologies element manager (WaveStar® ITM-SC). The inclusion of the radio system in the Lucent Technologies SDH product portfolio offers supervision of the complete network by the same element manager.

WaveStar® EOW

The engineering order wire (EOW) system is required by many operators for their private voice communications: it is used for commissioning and maintenance purposes but also to communicate along a parallel-utility network.This system is compatible with the whole Lucent Technologies SDH network element range.It is a stand-alone device.

Main features of the EOW are:

- Selective calling
- Group calling
- Global call
- Ring protection switching

The typical application is illustrated in Figure 6-3

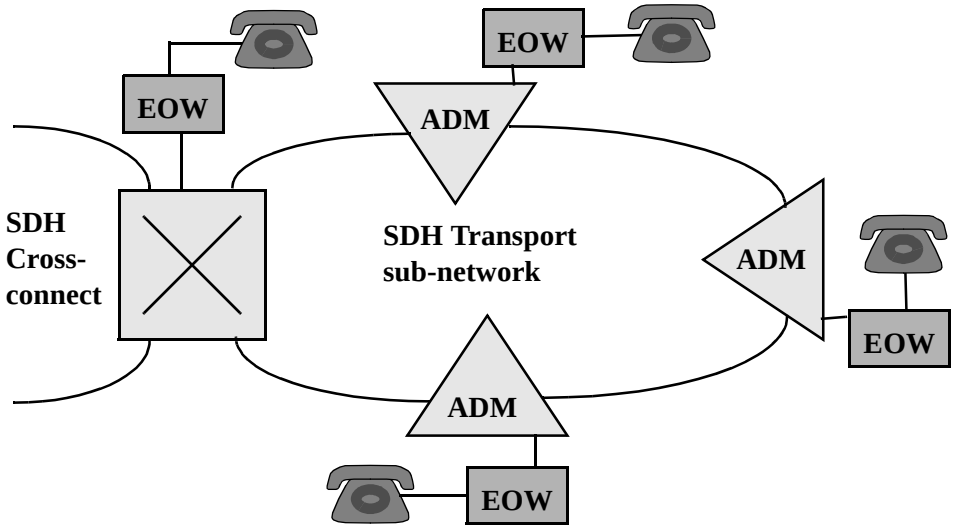


Figure 6-3. WaveStar® EOW in SDH ring

Network Management Systems

Navis™ Optical Management Solution

The Lucent Technologies Navis™ Optical Management Solution, offers modularity in management functionality, enabling Lucent Technologies to offer a customized set of management capabilities, dependent on the individual customer requirements.

The possible functionality of Navis™ Optical Management Solution in terms of ITU-management classes is:

- Fault and event management
- Configuration management
- Performance management
- Testing management
- Security management.

This functionality can be configured according to network management requirements on various levels, varying in size and functionality, thereby providing the possibility of maximally matching the network providers management needs, and accommodating a tunable system for the variety of wishes that network operators worldwide have.

This structure makes it possible to commence basic management capabilities at moderate costs at the beginning of a project, and add management functions when the network evolves to more sophisticated management capabilities.

To satisfy the management needs in various network management centers, Navis™ Optical Management Solution can be offered in different configurations, depending on the

needs in the particular management centers, offering management functionality in a tailored fashion.

Extension of capabilities of Navis™ Optical Management Solution with another management module, or addition of functionality within a module is realized by upgrading software, and might involve additional hardware.

Navis™ Optical Management Solution is compliant with the ITU architecture and recommendations mentioned in G.784.

Based on the required network management functions and used network elements, different modules are used to form the Navis™ Optical Management Solution:

- WaveStar® ITM-SC, a network element management system for the WaveStar® DACS 4/4/1, WaveStar® ADM 16/1, WaveStar® ADM 16/1 Compact, WaveStar® AM 1 Plus, WaveStar® AM 1, WaveStar® TM 1 and SDH radio.
- Navis™ Optical NMS, a network management system for transport networks.

WaveStar® ITM-SC

The element management system WaveStar® ITM-SC was developed to aid in the operation of SDH networks. The WaveStar® ITM-SC is a centralized management system for use with SDH network elements, which are interconnected either by optical or metallic lines operating at STM-1 (155 Mbit/s), STM-4 (622 Mbit/s) or STM-16 (2.5 Gbit/s). The management functions in the WaveStar® ITM-SC include both mediation and operation (OS) functions. It is also possible to relocate the OS functions to a physically separate system, leaving the WaveStar® ITM-SC to perform the role of mediator. In the absence of an OS, management can be performed using the network element local interface (ELI), which employs a large set of MML commands and a remote access feature to enable a user at one network element to perform and control and monitoring functions at any other connected network element. The Q2/Q3 model chosen for the WaveStar® ITM-SC is consistent with current thinking within the international standards community, in which Lucent Technologies NSI participates actively. Low-level filtering and message processing is performed and a higher level Q3 interface is provided. Since the standards are not yet finalized, any changes for WaveStar® ITM-SC to comply with the finalized version will be made as required.

Navis™ Optical NMS

The Navis™ Optical NMS provides centralized control and a comprehensive set of features and functions for the management of SDH and DWDM networks. The Navis™ Optical NMS is multi-vendor in nature and is able to support both Lucent Technologies and multi-vendor networks. The Navis™ Optical NMS module interfaces with the Navis™ Optical EMS and WaveStar® ITM-SC (Element Management) modules (for DWDM and SDH). The value of Navis™ Optical NMS lies in its ability to provide state-of-the-art network management capabilities that enable the service providers to differentiate from their competitors and provide them with a new source of revenue.

In particular Navis™ Optical NMS provides:

- End to end SDH Circuit Provisioning (auto and semi automatic and manual routing)
- End to end DWDM Optical Channel Provisioning (auto and semi automatic and manual routing)
- SDH Circuit Fault and Performance Management
- Optical Channel Fault and Performance Management
- JAVA based Graphical User Interface
- Northbound CORBA Interface to Service Management and Inter-domain Management Systems
- Scalable architecture to support 15,000 Network Element equivalents

Physical design

7

Introduction

The WaveStar® ADM 16/1 is Lucent Technologies' third generation of SDH equipment. In particular in the mechanical design of the system, the overall system requirements of compact design and flexibility where given special attention. This system has a volume of only one third of its previous generation.

To get big functional units, a design based on ETSI 600 x 600-mm footprint was developed. To keep the equipment on the right temperature over the whole operating temperature range, fans were introduced. These fans assure a uniform temperature pattern in the system for a reliable and long equipment life.

Another system requirement is its flexibility. On the STM-16 line side a variety of line port units can be placed and especially with the 9 tributary slots, almost every combination of trib units is possible. As a consequence, configurations with the WaveStar® ADM 16/1 are so flexible that at the moment of deployment, almost no precautions have to be made to be future proof for many years.

The Subrack

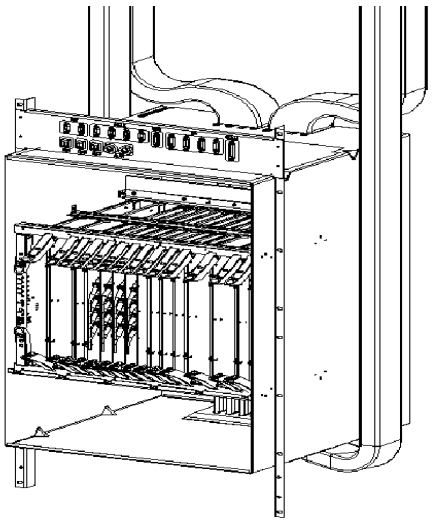
The WaveStar® ADM 16/1 subrack constructed in the new D700 construction is based on the ETSI floor space of 600x600 mm. Two subracks can be housed in an ETSI compliant rack.

The dimensions of the subrack are 750x500x545 mm (HxWxD). It is designed for front and rear access and consists of two major parts:

1. The equipment area that accommodates the plug-in units from front and backside.
2. The airflow areas of which one is located at the bottom of the subrack and one at the top. The lower airflow area is equipped with three self-contained fan units. Via the area at the top the cooling air exits the subrack.

Two out of three fans are enough for adequate cooling. In case of a malfunction a fan unit can be replaced in a subrack that is operational. The correct operation of the fans is monitored by an alarm system. The lower airflow area with fans is separated from the equipment area with a removable dust filter.

Figure 7-1. Subrack:



In the subrack there is room for:

- Two STM-16 line port units
- Two power and timing units (PTU) which operate in the 1+1 protection mode. One PTU can feed the whole subrack.
- Two cross-connect Units (CC) in 1+1 protection mode can be housed. If no equipment protection is needed, one unit is sufficient.
- One System Controller (SC) acts as the control interface to the Element Management Systems. The SC also handles the DCC channel. The SC is not involved in line or tributary transmission aspects and also the CC settings stay unchanged when the SC is removed.

- Additional 9 places for tributary slots are available.

The subrack is closed by metal face and rear plates with metal spring contacts.

The subrack with metal cover plates forms the EMC boundary of the WaveStar® ADM 16/1. Light guides are placed in the face plate in such a way, that the LED's on the SC can be monitored without opening the EMC area.

For ESD precautions, a person installing equipment must carry a bracelet. On front and backside of the Lucent Technologies racks an earth contact is provided to connect the bracelet to.

The printed circuit boards

The WaveStar® ADM 16/1 subrack can accommodate a number of circuit packs.

From the front side the big, almost rectangular, packs with a size of 3N can be inserted with the help of two latches per pack.

The so called paddle boards can be used at the rear side of the backplane. For each tributary unit, these paddle boards have to be used, in case of conversion and/or protection. Paddleboards are mechanically secured with a bar in the back of the system. Of the two paddle boards per slot the upper one sends its connecting cables to the top and the lower one sends its cables to the bottom of the subrack.

All circuit packs make use of the new 2 mm pitch connector system as generally used with the WaveStar® ADM 16/1.

There is one front inserted circuit pack which differs in size, namely the power and timing pack with a height of 1.5N. Those packs are located at the very right side of the subrack.

Apart from the System Controller which has several LEDs all other front packs have a LED for alarm purposes. On the optical paddle boards LEDs are also planned.

The dual WDM unit

A dual WDM unit can be placed in the subrack at the back. This unit supports co- and contra directional operation.

Within the WDM kit a bracket a bracket is included to mount the optical unit. 4 optical 0 dB SC connectors connect the two STM-16 units using universal connectors for FC built-outs. The two outputs are made with universal connectors with support SC of FC optical connectors.

With an extra bracket a second WDM can be mounted in the first WDM, which is placed within the subrack.

The interconnection panel (ICP)

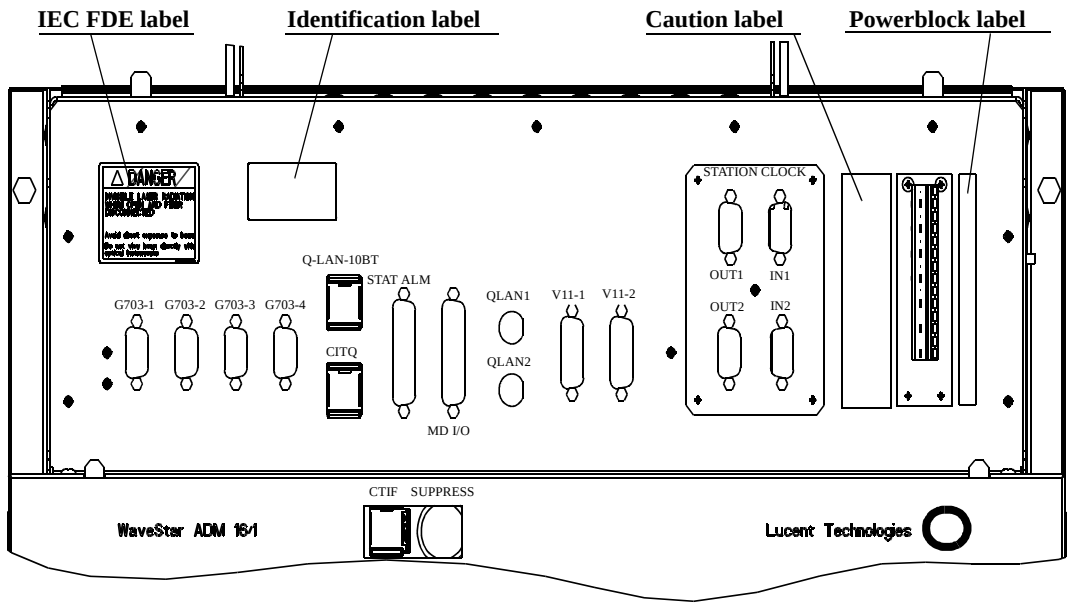


Figure 7-2. Interconnection Panel

The interconnection box forms the physical interface for the permanent and semi permanent supervision interfaces of the WaveStar® ADM 16/1. A suppress button like on the SC makes it possible to suppress alarms without opening the EMC boundary of the subrack.

The ICP is part of the subrack, but it has no cover in front of it.

A number of interfaces are available on the interconnection panel for:

- Timing
- Suppress button outside the EMC-boundary (similar to System Controller)
- Station alarms
- Miscellaneous discretes
- Access to overhead bytes
- Management interfaces.

Table 7-1. Connectors

Connector	Connector Type	Use
STATION CLOCK IN 1	D-SUB 9P MALE	External Timing input 1
STATION CLOCK IN 2	D-SUB 9P MALE	External Timing input 2
STATION CLOCK OUT 1	D-SUB 9P FEMALE	External Timing output 1
STATION CLOCK OUT 2	D-SUB 9P FEMALE	External Timing output 2
STATION ALARM	D-SUB 25P FEMALE	Station Alarm cabling
V11-1	D-SUB 15P FEMALE	Access to user overhead bytes, V.11 provisionable
V11-2	D-SUB 15P FEMALE	Access to user overhead bytes, V.11 provisionable
G703-1	D-SUB 9P FEMALE	Access to user overhead bytes, G.703 provisionable
G703-2	D-SUB 9P FEMALE	Access to user overhead bytes, G.703 provisionable
G703-3	D-SUB 9P FEMALE	Access to user overhead bytes, G.703 provisionable
G703-4	D-SUB 9P FEMALE	Access to user overhead bytes, G.703 provisionable
MD I/O	D-SUB 25P FEMALE	Miscellaneous input and outputs
Q-LAN-10BT	MODULAR JACK 8P	ITM SC connection, (Twisted Pair Ethernet)
QLAN1	BNC 50 Ohm FEMALE	Q-LAN cabling
QLAN2	BNC 50 Ohm FEMALE	Q-LAN cabling

Face plates for front access units

It is possible to equip the front access units with face plate. These face plates are designed in such, that mounting is also possible on already deployed units. In this way it is possible to create a uniform front sight of the WaveStar® ADM 16/1 with the front subrack cover removed.

The face plates are fully EMC and ESD safe.

For empty places dummy units are available in all sizes.

ETSI compliant racks 600x600 mm

Lucent Technologies can provide a number of dedicated ETSI compliant racks for housing of the WaveStar® ADM 16/1 subracks.

Table 1:

Rack Type	Remarks
ETSI Rack Frame 2200x600x600 mm (HxWxD)	assembled
ETSI Rack Frame 2200x600x600 mm (HxWxD)	as a kit
ETSI Rack Frame 2600x600x600 mm (HxWxD)	assembled
ETSI Rack Frame 2600x600x600 mm (HxWxD)	as a kit
Earthquake Proof Rack 2000x600x600 mm (HxWxD)	Assembled; zone 4 proof

The racks are equipped with full height doors on the front and the back. The 2600-mm rack version has a separate cover, which can be placed above the doors in case top access is required. The same cover can be placed under the doors when bottom access (for instance with computer floors) is required.

The assembled version of the 2600-mm rack is intended for top access.

Every rack can house two subracks.

There are limits in cabling flexibility related to the rack size. In general, the higher the rack the more flexible the cabling philosophy.

Each rack has two alarm lamps on front and back side for prompt and deferred maintenance alarms. The equivalent lamps of front and backside are set in parallel.

The four ETSI racks have standard improved fiber management. This means that fibers in the rack are housed in a tube which separates them from the electrical cables. So the fiber cables that are more vulnerable, are better protected and bow radii are also better maintained.

The ETSI racks have got one fiber guide standard mounted over the full working length of the rack.

For distribution of the power within the racks towards the subrack, a Power Distribution panel is needed. The panel has a function to secure the power network, by using automatic fuses, included as well.

Horizontal Connector Plate

The horizontal connector plate (HCP) is situated at the top of a rack. It is a combination of two metal plates covering together the whole 600x600 mm of rack surface in the top. The plates are completely filled with ‘holes’ to mount D-sub connectors. So the intra-rack 2 Mbit/s cabling ends on this position. The customer can connect its dedicated station cable to the corresponding D-sub connector of the WaveStar® ADM 16/1. The HCP is also used to mount the 34 Mbit/s up to STM-1e coax cabling. Two coax cables are used together with an adapter filler plate to mount two APT-1000 contacts (male) in the recoup.

The 2600 mm rack has enough room for two subracks with the intra rack cabling and the curves needed for the cabling. Within a 2200 mm rack, there is not enough bending area for the great number of 2 Mbit/s intra rack cabling area and there a lot of limitations become visible if two subracks have to be housed. Then the semi prefab cabling is a big relief..

Table 7-2. Overview of interface types, cables and connector

Interface type	Cable type	Connector type on connector plate	Number of cables/ connectors per slot
2Mbit/s	COAX	25 pins D-sub	16 8-fold
2Mbit/s	UTP	25 pins D-sub	16 8-fold
34/45 Mbit/s	COAX	APT-1000V	24 coax
140 Mbit/s	COAX	APT-1000V	8 coax
STM-1e	COAX	APT-1000V	8 coax
STM-0o	OPTICAL	Universal Built-out	24 fibers
STM-1o	OPTICAL	SC	8 fibers

Fiber Connector Conversion Kit

Today the number of optical channels, that from a mechanical or layout perspective can be placed on a board, is strongly dependent on the size of the optical send receiver module. The pitch between two modules depends heavily on the optical connector used.

All STM-4 and STM-16 optical packs (except for the WaveStar® OLS 1.6T compatible optics packs, these support LC connectors) are equipped with a universal built-out optical connector type, allowing the connector type to FC/PC or SC to be changed on-site depending on the customer needs.

The STM-1 optical circuit packs do have a SC-connection with a conversion possibility to FC/PC and LC.

The STM-0 does have a LC-connection (a miniature high performance connector design by Lucent Technologies) with a conversion possibility to FC/PC or SC.

The WaveStar® ADM 16/1 supports two ways of optical connector conversion:

1. In order to support FC and SC connectors, a fiber connector conversion kit has been defined. A total of 64 optical connections per subrack can be adapted in rack to the customer connector. This is enough to convert a completely filled subrack with STM-1 optical units from LC towards FC or SC.

   The optical conversion is done by a fiber with length of 0.5 m and an LC connector at one end and the universal connector at the other side. With the 0 dB adapter in the universal connector, the connector can be made FC or SC. Ordering is per 4 fibers, 0 dB adapters and mounting material in one orderable kit. The kit is defined in a way that 4 is the smallest number of optical interfaces per paddle board, and thus the smallest number that can be ordered. The customer does not have to order more conversion cables then needed with start up.

2. When conversion in the rack is no prerequisite longer conversion cables can be used. There is a number of cables which can be used from the optical system paddle board directly to the optical distribution frame (ODF). Both LC to FC and LC to SC are supported

These cables are also necessary when a number of optical contacts larger than 64 must be converted.

Table 7-3.

Length	**LC to FC**	**LC to SC**
5 m	yes	Yes
10	Yes	Yes
15	Yes	Yes
20	Yes	Yes
25	yes	yes

Improved in rack fiber guidance

In the latest racks standard improved fiber guidance is implemented.

The guides are square pipes mounted in the space between subrack and rack. In these pipes an endless cord is mounted to support the installing of fibers during installation or to install more fibers if the system is already operational.

The first fiber guides are mounted at the right of a rack looking from a front perspective. The initial guides are used for the STM-16 fibers and a limited number of for instance STM-1 optical fibers. When more fibers are used in a system, more guides should be mounted. It is important to realize, that due to the inflexibility of the guide material, mounting of fiber guides with subracks in place is not possible and the guides have to be mounted in a rack in the beginning.

When electrical and optical units are mixed in one rack, the fibers must be kept at the right and the electrical cabling at the left of the subracks. If only optical tributary interfaces are used, then fiber guides can be mounted at the left and the right.

Table 7-4.

		Number of fiber guides	
Fiber size	Max number of fibers	1 subrack	2 subracks
1.5 mm	20	1	2
1.5 mm	40	3	5
3 mm	18		

Cabling

The trend in the digital transmission industry is a rapid decrease in equipment volume and a rapid increase in density. This trend is particularly noticeable with the WaveStar® ADM 16/1. The WaveStar® ADM 16/1, Lucent Technologies' new generation of SDH equipment, has a very compact design. This causes a challenge for the mechanical engineers who are responsible for the design of the WaveStar® ADM 16/1 connections to the outside world, the transmission cabling. This is true for the electrical as well as for the optical cabling. For the WaveStar® ADM 16/1 a couple of new transmission cables has been designed. A new set of smaller cables was necessary to connect the great number of circuits in a WaveStar® ADM 16/1 to the DDF and the ODF.

Alternatives:

For electrical low and high frequent cabling and for fiber connections, the WaveStar® ADM 16/1 system supports two methods for transmission cabling:

1. On rack level an interface with standard electrical connectors (sub-D or APT-1000) and for fiber the customer requested connector (FC or SC) is delivered. The connection from the system to DDF or ODF is realized with customer defined cabling.
2. Semi prefab cabling with the 2-mm pitch equipment connector at one side for electrical cabling. LC connector on one fiber side and SC or FC connectors at the other end and fibers with sufficient length to go directly from equipment to the ODF.

Both methods have there own advantages.

Table 7-5.

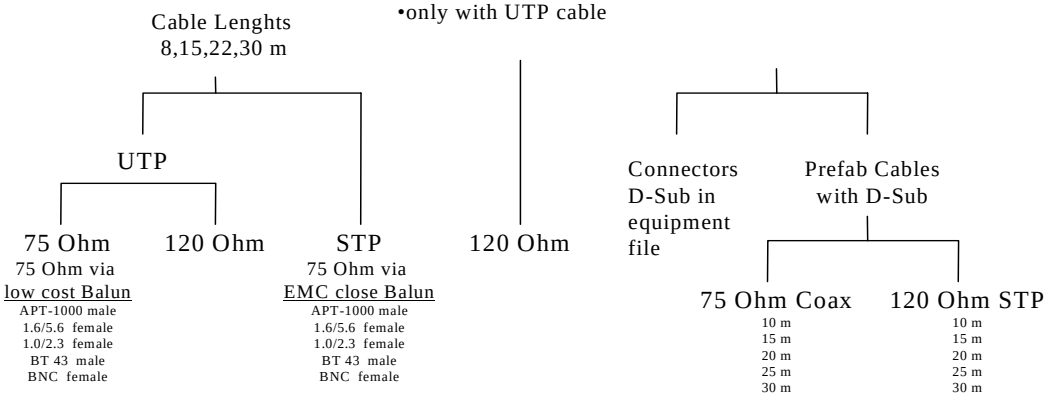
A: Customer Cabling	**B: Semi Prefab Cabling**
Expansive, one extra contact needed	Lowest cost
Less flexible with expansion later	Most flexible with expansion later
Local cable buy; exact cable length possible during installation	Cable to be ordered with a certain length; losses possible
For 75 Ohm coax expansive cable needed	75 Ohm via symmetrical lower cost cable and Balun connector
Different cables needed for 75 Ohm and 120 Ohm	For 75 and 120 Ohm the same cable can be used
For lengths greater then 30 m	

2 Mbit/s WaveStar ADM 16/1 Cabling Concept

I: Semi-Prefab Cabling
- plt-2 solution
- **120 Ohm PB's**
- **Preferred Solution**
- **Max flexibility**

II: No Cabling
- plt-1+2 solution
- **120 Ohm PB's**
- small numbers only
- 2 mm connectors in equipment file
- only with UTP cable

III: Intra Rack Cabling
- plt-1+2 solution
- **120 + 75 Ohm PB's**
- **Used with Customer Specific Cable**



Customer Cabling option A

The customer interface is situated in the top of the WaveStar® ADM 16/1 rack at the Horizontal Connector Plate (HCP) outside the subracks, outside the EMC boundary. Here a maximum of 1008 2 Mbit/s channels can be connected dependent of the rack size.

The connector philosophy is the same as used for ISM and SLM. That means SUB-D connectors for 2 Mbit/s for both 75 Ohm and 120 Ohm. The ISM prefab cables can be reused for the 2 MBit/s WaveStar® ADM 16/1 connections.

Pre-fabricated cables already in use with ISM speed up the installation work enormously, since no connectors have to be mounted in the field, which is very time consuming. Also, the quality of the connections will be much higher. And all cables are tested before they are shipped, so the number of cables that need to be repaired during installation test drops significantly.

For STM-1e, 34, 45 and 140 Mbit/s the APT-1000 coax connector is reused. For these frequencies no prefab cables from the HCP to the DDF is available. The cables from the APT-1000 contact on the HCP to the DDF is as with ISM and SLM constructed in the field during installation. In the field cable manufacturing is of course also possible for the 2 Mbit/s cabling.

Semi prefab electrical cabling option B

A concept of semi-prefab cables for the 2 Mbit/s connection had been developed. This means that the equipment side of a 2 Mbit/s cable is pre-connected with the 2-mm equipment connector. The cable is available in 8,15,22 and 30 m such that most equipment to DDF distances can be bridged.

For a number of reasons Lucent has developed one type of 2 Mbit/s cable for 75 as well as for 120 Ohm. This means that it is possible to use shielded twisted pair (STP) cable to connect the WaveStar® ADM 16/1 to the DDF. The impedance transformation for 75 Ohm is realized in a special so-called Balun connector that can directly be connected to the customer DDF.

Lucent supports the 1.6/5.6, BT-43, BNC and the APT-1000 connectors on the 75-Ohm side of the DDF.

For the lowest cost a solution with UTP cable is possible. Wire wrap to a 120-Ohm DDF or even using a low cost non-EMC close Balun for 75-Ohm connectivity is possible. Cable lengths identical as for the STP cable: 8,15,22 and 30 m.

The semi prefab cables can be connected, with the equipment connector side, directly to the 120-Ohm paddle boards 2-mm Pitch connector.

There is a third way to connect cables to the WaveStar® ADM 16/1 and that is completely field made cables.

There are installation tools available to connect cable with the correct specifications to a 2-mm pitch connector with IDC contacts. This is however, because of the expected unreliability of the connections and the expansive tools a non-preferred solution. Only used for limited repair functions.

System Planning and Engineering

8

Overview

This chapter summarizes the descriptive information used for system planning. It describes the basic engineering rules for the WaveStar® ADM 16/1 Multiplexer and Transport System.

Network Planning

There are a number of issues to consider when planning a network. Projected customer requirements determine the network topology and traffic capacities needed, both initially and in the future. These considerations drive, in their turn, the equipment planning and physical installation. In addition synchronization and management need to be planned.

The building constructed or selected to serve as a terminal office or repeater site should be inspected and an overall plan developed before the equipment is ordered and installed. This plan should consider the eventual system size and include the following:

- Synchronization
- Protection
- Capacity
- Span length (Chapter 9)
- Optical line loss budget (Chapter 9)
- Floor-plan layout
- Equipment interconnection (Chapter 9)
- Cabling (Chapter 7)
- Environmental considerations (Chapter 9)
- Power planning (Chapter 9).

Lucent Technologies offers engineering and installation services to plan and install the WaveStar® ADM 16/1 system and related systems. For more information about Lucent Technologies engineering and installation services refer to Chapter 11 “Product Support”.

Network Synchronization

Introduction

The planning of the synchronization network should be considered for the network as a whole. The guidelines for synchronization network engineering can be found in ITU-T Recommendation G.803, Annex III. The WaveStar® ADM 16/1 supports all synchronization features needed (as specified in ITU-T Recommendation G.781, Option 1) to engineer the network synchronization according to ITU-T Recommendations.

Careful consideration should be given to the correct design of the SDH network's synchronization. Proper synchronization engineering minimizes timing instabilities, maintains quality transmission network performance and limits network degradation due to unwanted propagation of network synchronization faults.

The following list contains some key recommendations in respect to network synchronization:

- A group of inter-connected SDH network elements, which all contain an internal clock according to G.813 option 1, like the WaveStar® ADM 16/1, form, from a synchronization point of view, a so-called "SEC sub-network". All SDH network elements in this cloud provide each other timing information via STM-N links. Such a network part should receive, via at least two independent paths, synchronization from the network clock, usually a PRC (See ITU-T Recommendation G.811) and a back-up clock (usually an SSU according to G.812), in case the PRC fails.
- 2 MHz and 2 MBit/s links are used to bring in the timing information from the network clock into the SEC sub-network. The planning of the links between the PRC and all SSUs in a network are part of the over-all operator's network synchronization plan.
- Within the SEC sub-network the SDH network elements should be configured in such way that each network element receives at least two reference signals. Selection between the alternative references should be based on the SSM protocol
- When engineering the SEC sub-network synchronization one should avoid that chains of SECs are present or can be formed which exceed the number of 20 nodes (excluding SDH regenerators).
- As a guideline, it is recommended to engineer the SEC sub-network synchronization in such a way that undor no combination of two independent failures, timing loops can be created or instabilities in the reference selectors occur.

The WaveStar® ADM 16/1 meets ITU-T Recommendation G.781 and supports the following features to support the engineering of the synchronization network:

- Possibility to assign STM-N inputs (both aggregate and tributary), 2 Mbit/s traffic inputs and external synchronization inputs (2 MHz or 2 Mbit/s) as references for the system or the external synchronization output.

- Assignment/Unassignment of synchronization references. Up to 8 references can be assigned (two external timing inputs, two aggregate interfaces and four tributary interfaces). Each can be provisioned with a priority
- Independent selection of references for the system clock and the external timing output.
- Optional enabling/disabling of the SSM algorithm.
- Within the SSM algorithm it is possible to assign a fixed SSM value to any incoming reference and to define a squelch threshold for the external synchronization output

WaveStar® ADM 16/1 System Planning and Engineering

Subrack layout

The WaveStar® ADM 16/1 program contains a subrack for applications up to 504 x 2 Mbit/s Add/Drop capacity or a maximum of 8 x STM-4. Dimensions: 750 x 500 x 545 (HxWxD) mm. This subrack is called the High-density subrack.

The system circuit packs are cooled by an integrated fan-unit. It forms part of the WaveStar® ADM 16/1 subrack. An InterConnection Panel (ICP) is integrated within the subrack (EFA4). The following can be made available on the ICP: Overhead Channels, Station Alarms, Miscellaneous Discrete Inputs and Outputs and several network management connectors.

High-density or 9 tributary-slot subrack (EFA4)

The WaveStar® ADM 16/1 high-density subrack contains 16 slots in which the following circuit packs can be inserted from the front:

Table 8-1.

Slot position	Abbreviation	Slot name
1	SC	System Controller
2, 13	CC1, CC2	Cross-connect
3, 14	LS1, LS2	Line-interface Position
4, 5, 6, 7, 8, 9, 10, 11, 12	TS1 - TS9	Tributary Interface Position
15, 16	PT1, PT2	Power and Timing

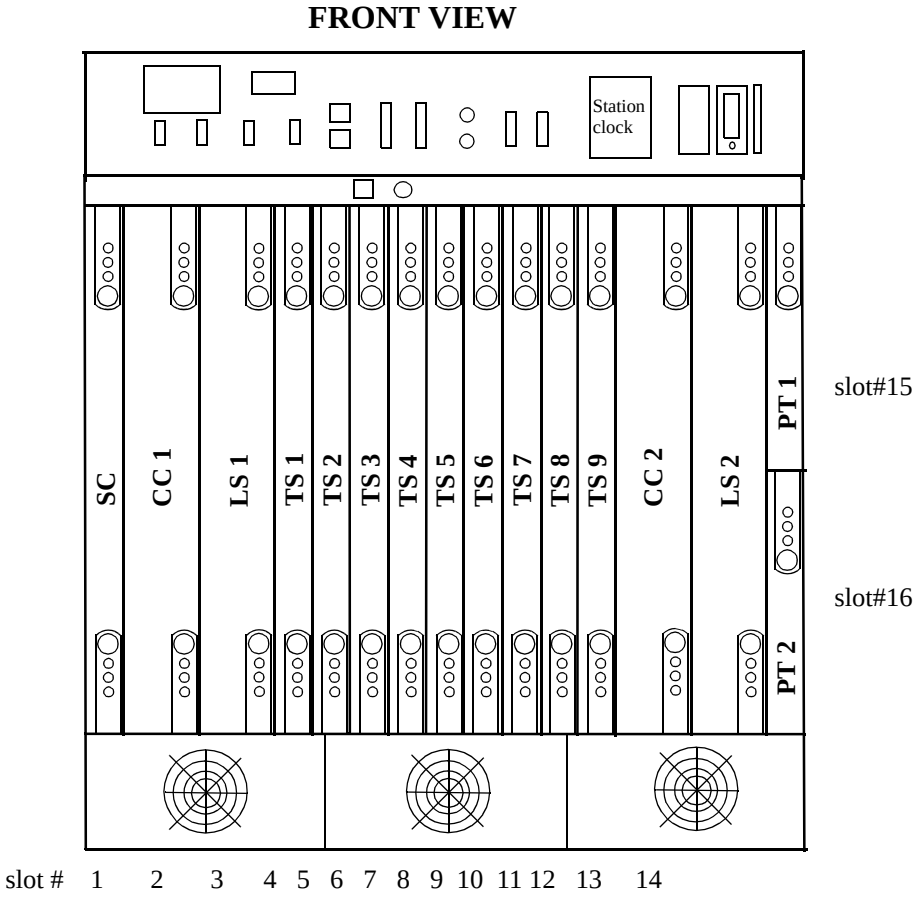


Figure 8-1. WaveStar® ADM 16/1 EFA4 high-density subrack

Overview of Position of Interface circuit packs in the WaveStar® ADM 16/1 subrack

General

- System Controller Slot SC: slot #1
- Crossconnect slot CC1 and CC2: slot #2 and #13
- Line slots LS1 and LS2: slot #3 and #14
- Tributary slots TS1-TS9: slot #4 up to #12
- Power and Timing slots PT1 and PT2: slot #15 and #16

The WaveStar® ADM 16/1 subrack has a maximum 9 slots available for Tributary circuit packs.

Exceptions to the rule

All tributary slots of the High-density subrack can be used for regular traffic, with the following exceptions:

- Slot 4:

  In case an SI-1/4, PI-E4/4, SPIA-1E4/4B (used in E4 or STM-1 electrical mode) or SIA-1/4B (used in STM-1 electrical mode) tributary unit is inserted in slot 4, this unit is always considered the protecting unit in the 1:N (N = 1, .., 4) equipment protection scheme for STM-1 electrical or E4 interface cards. This means that it is not possible to have regular traffic carrying unit of those types in slot 4.

  If case no STM-1 equipment protection is needed, this slot can be used for one of the following cards:

  - PI-DS1/63 (protected or un protected)
  - PI-E1/63 (protected or unprotected)
  - PI-DS3/12 or PI-E3DS3/6+6 (protected or unprotected)
  - PI-E3/6 (protected or unprotected)
  - PI-DS3/6 (protected or unprotected)
  - SA-1/4B (MSP protected or unprotected)
  - SI-S4.1/1 (MSP protected or unprotected)
  - SPIA-1E4/4B used in STM-1 optical mode (MSP protected or unprotected)
  - SIA-1/4B (MSP protected or unprotected)
  - SA-0/12 (MSP protected or unprotected)
  - IP-LAN/8 Tlan+ (unprotected)
  - IP-GE/2 (Gigabit Ethernet option card, unprotected)

NOTE:
STM-1 electrical and E4 units can be equipment protected at the same time by using a SPIA-1E4/4B in slot 4. The SPIA-1E4/4B automatically configures itself in the correct operation mode. Additionally in R4.0 it is possible to in-service upgrade an older E4 or STM-1e unit in a worker slot to a SPIA-1E4/4B or SIA-1/4B unit. A SPIA-1E4/4B or SIA-1/4B unit in a worker slot **can not be protected** by an older E4 or STM-1e unit in slot 4, even not when both units are running in the same mode.

NOTE:
The SA-1/4B and SPIA-1E4/4B or SA-1/4B and SIA-1/4B **can not be used in the same MSP protection group**.

- Slot 12:

In case a PI-E1/63 or PI-DS1/63 tributary unit is inserted in slot 12, this unit is always considered the protecting unit in the 1:N (N = 1, .., 8) equipment protection scheme for E1 or DS1 interface cards. This means that it is not possible to have regular traffic carrying unit of those types in slot 12.

If no 1.5 or 2 Mbit/s equipment protection is needed this slot can be used by one of the following cards:

- SPIA-1E4/4B used in STM-1E or E4 mode (unprotected only)
- SIA-1/4B used in STM-1E mode (unprotected only)
- SI-1/4 (unprotected only)
- PI-E4/4 (unprotected only)

NOTE:
DS1 and E1 units can not be equipment protected at the same time. The unit type entered in slot 12 determines whether E1 or DS1 units can be protected.

The following overview indicates the Tributary port circuit packs and the position they can have in the WaveStar® ADM 16/1 subrack:

Table 8-2.

Circuit pack (CP) Function	**Circuit Pack Name**	**Possible slot position in WaveStar™ ADM 16/1**
Tributary port 1.5 Mbit/s signals - worker/unprotected	PI-DS1/63	4, 5, 6, 7, 8, 9, 10 or 11
Tributary port 1.5 Mbit/s signals - eqpt. protection	PI-DS1/63	12 (protects 4 through 11)
Tributary port 2 Mbit/s signals - worker/unprotected	PI-E1/63	4, 5, 6, 7, 8, 9, 10 or 11
Tributary port 2 Mbit/s signals - eqpt. protection	PI-E1/63	12 (protects 4 through 11)
Tributary port 34 and 45 Mbit/s signals - worker/unprotected	PI-E3DS3/6+6	4, 5, 6, 7, 8, 9, 10 or 11
Tributary port 34 and 45 Mbit/s signals - eqpt. protection	PI-E3DS3/6+6	5 (protects 4), 7 (protects 6), 9 (protects 8) or 11 (protects 10)
Tributary port 45 Mbit/s signals - worker/unprotected	PI-DS3/12	4, 5, 6, 7, 8, 9, 10 or 11
Tributary port 45 Mbit/s signals - eqpt. protection	PI-DS3/12	5 (protects 4), 7 (protects 6), 9 (protects 8) or 11 (protects 10)
Tributary port 45 Mbit/s signals signals - worker/unprotected	PI-DS3/6	4,5,6,7,8,9,10 or 11
Tributary port 45 Mbit/s signals signals - eqpt. protection	PI-DS3/6	5 (protects 4), 7 (protects 6), 9 (protects 8) or 11 (protects 10)
Tributary port 34 Mbit/s signals signals - worker/unprotected	PI-E3/6	4,5,6,7,8,9,10,or 11

Table 8-2.

Tributary port 34 Mbit/s signals signals - worker/unprotected	PI-E3/6	5 (protects 4), 7 (protects 6), 9 (protects 8) or 11 (protects 10)
Tributary port STM-0 signals - worker/unprotected	SA-0/12	4, 5, 6, 7, 8, 9, 10 or 11
Tributary port STM-0 signals - MSP protection	SA-0/12	5 (protects 4), 7 (protects 6), 9 (protects 8) or 11 (protects 10)
Tributary port 140 Mbit/s signals - worker/unprotected	PI-E4/4 SPIA-1E4/4B (E4 mode)	5, 6, 7, 8, 9, 10, 11 or 12
Tributary port 140 Mbit/s signals - eqpt. protection	PI-E4/4 SPIA-1E4/4B (E4 mode)	4 (protects 5, 6, 7 and/or 8)
Tributary port STM-1E signals - worker/unprotected	SI-1/4 SPIA-1E4/4B (STM-1E mode) SIA-1/4B (STM-1E mode)	5, 6, 7, 8, 9, 10, 11 or 12
Tributary port STM-1E signals - eqpt. protection	SI-1/4 SPIA-1E4/4B (STM-1E mode) SIA-1/4B (STM-1E mode)	4 (protects 5, 6, 7 and/or 8)
Tributary port STM-1O signals - worker/unprotected	SA-1/4 SA-1/4B SPIA-1E4/4B (STM-1O mode) SIA-1/4B (STM-1O mode)	4, 5, 6, 7, 8, 9, 10 or 11
Tributary port STM-1O signals - MSP protection	SA-1/4B SPIA-1E4/4B (STM-1O mode) SIA-1/4B (STM-1O mode)	5 (protects 4), 7 (protects 6), 9 (protects 8) or 11 (protects 10)
Tributary port STM-4 signals - worker/unprotected	SI-S4.1/1 SI-L4.2/1	4, 5, 6, 7, 8, 9, 10 or 11
Tributary port STM-4 signals - MSP protection	SI-S4.1/1 SI-L4.2/1	5 (protects 4), 7 (protects 6), 9 (protects 8) or 11 (protects 10)
LAN interface unprotected	IP-LAN/8 IP-LAN 8 Tlan+	4, 5, 6, 7, 8, 9, 10 or 11
Gigabit Ethernet interface unprotected	IP-GE/2	4,5,6,7,8,9,10,11 or 12

Circuit pack naming

The circuit packs described below can be used in the high-density subrack of the WaveStar® ADM 16/1. Some of the Interface circuit packs of the WaveStar® ADM 16/1 can be inserted in a Line or a Tributary slot, they are pin-compatible.

Table 8-3.

Circuit Pack (CP) Name	**Description**
SI	Synchronous Interface
PI	Plesiochronous Interface
IP	Internet Protocol
SPIA	Synchronous and Plesiochronous Adapter Interface
SIA	Synchronous Adapter Interface
PB	paddle board
SA	Synchronous Adapter
TI	Timing Interface
OI	Optical Interface
LBPA	Line Booster Pre-Amplifier
SC	System Controller
CC	Cross-Connect
PT-stnd	Power and Timing CP standard
PT-str3	Power and Timing CP ± 0.37ppm
Interface Type	**Description**
U 16.2	Ultra Long-haul, STM-16, 1550 nm
V 16.2	Very-haul optical, STM-16, 1550 nm
L 16.3	Long-haul optical, STM-16, 1550 nm
L 16.2	Long-haul optical, STM-16, 1550 nm
L 16.1	Long-haul optical, STM-16, 1310 nm
L 4.2	Long haul optical, STM-4, 1550 nm
S 4.1	Short haul optical, STM-4, 1310 nm
L 1.2	Long haul optical, STM-1, 1550 nm
S 1.1	Short haul optical, STM-1, 1310 nm
S 0.1	Short haul optical, STM-0, 1310 nm
I 1.1	Intrastation optical, STM-1, 1310 nm
16EML.x/1 (x from 9190 to 9585)	STM-16, 1530- 1565 nm, interworking with the WaveStar OLS 1.6T
0	STM-0, 1310 nm
1	STM-1 electrical
E4	140 Mbit/s

Table 8-3.

DS3	45 Mbit/s
E3	34 Mbit/s
E1	2 Mbit/s
DS1	1.5 Mbit/s
LAN	Local Area Network
paddle board Type	**Description**
75	75 Ω through connection board, no protection relays
100	100 Ω converter, no protection relays
120	120 Ω converter, no protection relays
P75	75 Ω converter with protection relays
P100	100 Ω converter with protection relays
P120	120 Ω converter with protection relays
PP	STM-1E/E4 protection selector/bridge (protection version)
PW	STM-1E/E4 protection selector/bridge (worker version)

Naming examples:

SPIA-1E4/4: Synchronous and Plesiochronous Adapter circuit pack, STM-1 and 140 Mbit/s, 4 channels per circuit pack.

PB-E1/P75/32: paddle board, 75 Ω, used for protection, 32 channels per paddle board.

Core engineering WaveStar® ADM 16/1.

The core configuration of the WaveStar® ADM 16/1 always consists of the following.

Table 8-4.

Circuit Pack (CP) Name	Item Code	Comcode	Description	Number	Slot position	Remark
Subrack 9TAD B	EFA4	848414710	Subrack 9TAD (700) B	1	N.A.	
SC SC2	LJB400 LJB457B	107870446 108829813	System Controller	1	1	
-			WaveStar® ADM 16/1 system software	1	n.a.	1

Table 8-4.

-			WaveStar® ADM 16/1 backup software	1	n.a.	2
CC-64/32 CC-64/32B	LJB420 LJB420T LJB434	108244104 108988320 108645581	Cross-Connect CPs	1	2	3
PT-stnd PT-str3	LMB400 LMB401	107870057 107870453	Power Filter and Timing CPs	1	16	4

Remarks:

1. System software is downloaded to the SC in the factory.
2. Backup software is delivered on tape (WaveStar® ITM-SC) or on a disk (ITM-CIT).
3. If CC protection is required, an additional CC circuit pack should be engineered slot #13.
4. If PT protection is required, an additional PT circuit pack should be engineered slot #15.

Depending on required hold-over stability, two versions of the PT circuit pack are available

- PT-stnd. This unit meets the specifications of G.813 option 1. Lifetime oscillator accuracy: ± 4.6 ppm
- PT-str3. This unit meets the specifications of G.813 option 1. Lifetime oscillator accuracy: ± 4.6 ppm. In addition the hold-over stability for the first 24 hours of hold-over is specified at ± 0.37 ppm.

Line interface units

The following line interfaces are available now or supported from previous releases:

Table 8-5.

Circuit Pack (CP) Name	Item Code	Comcode	Description	Slot position	Remark
SI-L16.1/1C SI-L16.1/1D	LJB425B LJB435	108441981 108647215	Line-port long-haul 2.5 Gbit/s 1310 nm, according table L 16.1 in G.957, one interface per CP	3, 14	1, 3
SI-L16.2/1C SI-L16.2/1D	LJB426B LJB436	108441999 108647223	Line-port long-haul 2.5 Gbit/s 1550 nm, according tables L 16.2 and L16.3 in G.957, one interface per CP	3, 14	1, 3

Table 8-5.

SI-L16.3/1B **Limited Availability !**	LJB419B	108442005	Line-port long-haul 2.5 Gbit/s 1550 nm, 4 dB better than tables L 16.2 and L16.3 in G.957, one interface per CP	3,14	1, 3, 4
SI-L16.3/1Y **Limited Availability !**	LJB419Y	108442013	Factory selected line-port long-haul 2.5 Gbit/s 1550 nm, 6 dB better than tables L16.2 and L16.3 in G.957, one interface per CP	3,14	1, 2, 3, 4
SI-EMLU16.2/1 **Limited Availability !**	LJB423	108278086	Interface Port 2.5 Gbit/s with EML transmitter to interwork with booster/pre-amplifier, one interface per CP	3, 14	4
LPBA-U16.2/1	LJB413	107870313	Booster/Pre-amplifier unit for U-16.2 and U-16.3 applications G.691	4, 5, 6, 7, 8, 9, 10, 11 or 12	
LBA-V16.2/1	LJB433	108648841	Booster unit for V-16.2 and V-16.3 applications G.691	4, 5, 6, 7, 8, 9, 10, 11 or 12	
SI-16EML80.1/1 through SI-16EML80.16/1 **Limited Availability !**	LJB441 through LJB456	108278xxx	Interface port 2.5 Gbit/s EML, to WaveStar® OLS 80G, one wavelength per CP	3, 14	4
SI-16EML9xxx/1	LJB501 through LJB580	10844xxxx	Interface port 2.5 Gbit/s EML, to WaveStar® OLS 1.6T, one wavelength per CP	3,14	1

Remark:

1. All STM-16 optical packs, except for **SI-16EML9xxx/1** which supports an LC-connector, support the universal build-out optical connector type. This connector type supports both FC/PC and SC optical connectors. For power budget details please refer to Chapter 9.
2. The "ITU-T + 6dB" units are only available in limited quantities. Specific requests should be made to Product Mangement.
3. The units SI-L16.1/1C, SI-L16.2/1C, SI-L16.3/1B and SI-L16.3/1Y support reporting of analog optical parameters (optical transmit power, optical received power, laser bias current).
4. **Discontinued Availability (DA) in April 2002!**

Optical tributary interfaces

The following line interfaces are available now or supported from previous releases:

Table 8-6.

Circuit Pack (CP) Name	Item Code	Comcode	Description	Slot position	Remark
SA-0/12	LJB421	108275587	STM-0 adapter board for four STM-0 interfaces. Supports AU-3/TU-3 conversion, MSP and loopbacks	4 thru 11	1
OI-0/6	PBD3	108333436	STM-0 1310 nm; 6 Interfaces per interface board.	behind 4 thru 11	1
SPIA-1E4/4B	LJB431B LJB431T	108681651 108988312	STM-1 adapter board for four STM-1 optical interfaces in AU-4 or AU-3/TU-3 conversion mode. Supports MSP, tributary DCC and loopbacks	4 thru 11	2,4
SIA-1/4B	LJB439B LJB439T	108884610 108988338	STM-1 adapter board for four STM-1 optical interfaces in AU-4 or AU-3/TU-3 conversion mode. Supports MSP, tributary DCC and loopbacks	4 thru 11	2,4
OI-S1.1/2SC	PBD4	108584962	Optical Short haul STM-1 1310 nm; 2 Interfaces per interface board	behind 4 thru 11	2, 5
OI-L1.2/2	PBA10	108600800	Optical Long haul STM-1 1550 nm; 2 Interfaces per interface board	behind 4 thru 11	2
SI-L4.2/1	LJB405C	108862509	Optical Long haul STM-4 1550 nm; Supports AU-4-4c, AU-4 and AU-3/ TU-3 conversions	behind 4 thru 11	3
SI-S4.1/1	LJB416B	108681669	Optical Short haul STM-4 1310 nm. Supports AU-4-4c, AU-4 and AU-3/ TU-3 conversion, MSP, DCC and loopbacks	4 thru 11	3
IP-GE/2	LJB460	109198226	Gigabit Ethernet option card	4 thru12	

Remarks:

1. One or two OI-0/6 optical paddle boards have to be installed behind each SA-0/12 STM-0 circuit pack. Each paddle board provides 6 optical interfaces with LC connector type.
2. One or two OI-S1.1/2 or OI-L1.2/2 optical paddle boards have to be installed behind each SPIA-1E4/4B or SIA-1/4B STM-1O circuit pack. Each paddle board provides 2 optical interfaces with SC connector type. A mix of OI-S1.1/2 and OI-L1.2/2 is allowed behind SPIA-1E4/4B or SIA-1/4B STM-1O circuit pack.
3. The optical interface is integrated on the STM-4 main board. No optical adapter units are needed.

4. The SA-1/4 and SA-1/4B units are no longer available and replaced by SPIA-1E4/4B and SIA-1/4B.
5. The PBD2 has been DA'ed. For customers that require STM-1O interfaces with LC-connectors a patchcord can be used. Comcode: 108113853, 4 ft LC-SC Connector

Electrical tributary interfaces

The following line interfaces are available now or supported from previous releases:

Table 8-7.

Circuit Pack (CP) Name	Item Code	Comcode	Description	Slot position	Remark
PI-E1/63	LJB411 LJB411T	107870339 108988304	2 Mbit/s, 75 Ω 63 interfaces per CP	4-12	1
PI-DS1/63	LJB430	108442021	1.5 Mbit/s, 75 Ω 63 interfaces per CP	4-12	2
PI-E3DS3/6+6	LJB427	108330366	34 and 45 Mbit/s 6 interfaces of each type per CP	4-11	
PI-DS3/12	LJB424	108281387	45 Mbit/s 12 interfaces per CP	4-11	
PI-DS3/6	LJB461	109198234	6 interfaces, 45Mbit/s	4-11	
PI-E3/6	LJB462	109198242	6 interfaces, 34Mbit/s	4-11	
PI-E4/4	LJB414	107880148	140 Mbit/s 4 interfaces per CP	4-12	3, 5
SPIA-1E4/4B	LJB431B LJB431T	108681651 108988312	140 Mbit/s / STM-1E 4 interfaces per CP	4-12	3
SIA-1/4B	LJB439B LJB439T	108884610 108988338	STM-1E 4 interfaces per CP	4-12	3
IP-LAN/8	LJB458	108567488	10/100 Mbit/s Base-T 8 interfaces per CP	4-11	
IP-LAN 8 Tlan+	LJB459	109107383	10/100 Mbit/s Base-T 8 interfaces per CP, TransLAN	4-11	

Remarks:

1. Equipment protection functionality is provided by the circuit pack in tributary slot 12. Impedance adaptation to 75/120 Ω and/or equipment protection functionality can be provided by additional paddle boards.

2. Equipment protection functionality is provided by the circuit pack in tributary slot 12. Impedance adaptation to 100 Ω or equipment protection functionality can be provided by additional paddle boards.
3. Equipment protection functionality can be provided by additional paddle boards.
4. Equipment protection functionality is provided by the circuit pack in tributary slot 4 and paddle boards.
5. In the Sapphire release the PI-E4/4 is no longer available. It is replaced by the SPIA-1E4/4B.
6. In the Sapphire release the SI-1/4 is no longer available. It is replaced by the SPIA-1E4/4B or SIA-1/4B.

Timing and synchronization interfaces (DS0 markets; Japan and USA)

These timing interfaces are available for the markets in Japan.

Table 8-8.

Circuit Pack (CP) Name	Item Code	Comcode	Description	Slot position	Remark
TI-DS2DS0/1	LJC400	108095654	Timing Interface board 64+8 kHz Sync Input + 6312 kHz Sync Output	Behind PT-stnd	1

Remark:

1. A maximum of 2 x TI-DS2DS0/1 can be engineered per subrack.

Paddle boards (electrical interfaces)

A variety of paddle boards exists to interconnect the system directly or indirectly to the office cabling. In addition, paddle boards can be used for equipment protection and/or impedance adaptation. All paddle boards can be inserted from the rear of the equipment and fit to the 2 mm pitch back-plane connectors.

Paddle boards are always needed for 1.5 Mbit/s and 2 Mbit/s interfaces. Other electrical interface types can be used without paddle boards (if protection is not needed now or in the future).

Paddle boards are half height boards and two paddle boards have to be mounted behind each corresponding main board to be able to access all interface ports. Also if less than half the interfaces on a unit have to be cabled, it is still necessary to equip both paddle boards to get a valid configuration. The two paddle boards behind each unit have to be identical and are mounted in 180° mirrored fashion.

Table 8-9.

Protection and Impedance conversion 1.5 Mbit/s paddle boards (PB)					
PB Name	**Item Code**	**Comcode**	**Description**	**Position**	**Notes**
PB-DS1/100/32	PBA6	108442047	Conversion to 100 Ω, 32 channels, unprotected applications	Behind each unprotected PI-DS1/63, Slot 4-11.	1
PB-DS1/P100/32	PBA7	108442054	Conversion to 100 Ω, 32 channels, protected applications	Behind each worker PI-DS1/63, Slot 4-11.	1,2
Protection and Impedance conversion 2 Mbit/s paddle boards (PB)					
PB-E1/75/32	PBA3	107967952	Unprotected 75 Ω applications, 32 channels	Behind each unprotected PI-E1/63, Slot 4-11.	3
PB-E1/P75/32	PBA1	107967937	Protected 75 Ω applications, 32 channels	Behind each worker PI-E1/63, Slot 4-11.	3
PB-E1/120/32	PBA4	107967960	Conversion to 120 Ω, 32 channels, unprotected applications	Behind each unprotected PI-E1/63, Slot 4-11.	3
PB-E1/P120/32	PBA2	107967945	Conversion to 120 Ω, 32 channels, protected applications	Behind each worker PI-E1/63, Slot 4-11.	2, 3
paddle boards for 34/45 Mbit/s:					
PB-E3DS3/P/6	PBC2	108330382	6 channels, 1+1 equipment protection application	Behind each worker/protection pair in slots 4/5, 6/7, 8/9 or 10/11. The paddle board straddles two slot positions	4
paddle boards for STM-1 and 140 Mbit/s:					
PB-1E4/PW/2	PBA5	107972218	Protect PB, 2 ch. for STM-1 and 140 Mbit/s, worker unit version	Behind worker STM-1E or E4 units, slot positions 5-8	5, 6

Table 8-9.

PB-1E4/PW/2 Cx	PBA8	108538646	Protect PB, 2 ch. for STM-1 and 140 Mbit/s, worker unit version, coax interfaces	Behind worker STM-1E or E4 units, slot positions 5-12	5, 6
PB-1E4/PP/2	PBB1	107972382	Protect PB, 2 ch. for STM-1 and 140 Mbit/s, protection board version	Behind protection STM-1E or E4 unit, PB slot position XP01&XP02	5
PB-LAN	PBA9	108573056	PB behind the LAN interface unit	Behind LAN units, slot position 4-11	

Remarks:

1. This paddle board can be used with the PI-DS1/63.
2. No paddle board is needed behind the protecting DS1 or E1 circuit pack, slot position 12.
3. This paddle board can be used with the PI-E1/63.
4. This paddle board can be used with adjacent pairs of PI-DS3/12 or PI-E3DS3/6+6 units or with the PI-DS3/6 or PI-E3/6.
5. This paddle board can be used with the SI-1/4, PI-E4/4, SIA-1/4B (in STM-1E mode) and SPIA-1E4/4 (in STM-1E or E4 mode).
6. If 1:N protection is needed at a later time, the worker unit paddle boards have to be installed immediately (in through mode). Later the protection unit paddle board can be added in an in-service upgrade.

Configurations

WaveStar® ADM 16/1 Terminal STM-16 (0 x 1, all interfaces)

Table 8-10.

	Circuit Pack (CP) Name	Description	Number	Remark
Subracks				
1	EFA 4	High-density subrack	1	
Core circuit packs				
3	SC SC2	System Controller	1	
5	CC-64/32 CC-64/32B	Cross-Connect CP 64 x 64 HO, 32 x 32 LO	2	1
7	PT-stnd	Power and Timing CP ± 4.6 ppm	2	2
8	PT-str3	Power and Timing CP ± 0.37 ppm		
Line-interface circuit packs				
9	SI-L 16.1/1C SI-L16.1/1D	Long-haul 2.5 Gbit/s 1310 nm, L 16.1, ITU range	2	3
10	SI-L 16.2/1C SI-L 16.2/1D	Long-haul 2.5 Gbit/s 1550 nm, L 16.2 , ITU range		
13	SI-16EMLx/1	Interworking packs OLS 1.6T (80 different wavelengths)		
Boosters and pre-amplifier circuit packs				
14a	SI-EMLU16.2/1	EML 2.5 Gbit/s 1550 nm U 16.2		
14b	LPBA-U 16.2/3	Booster and Pre-Amplifier (160km)		
14c	LBA-V16.2/1	Booster (120km)		
Optical tributaries				
15	SA-0/12	Converter board STM-0		
15a	OI-0/6	Optical Interface STM-0 1310 nm		
16	SI-S 4.1/1	Short Haul, STM-4 1310 nm	2	
Optical / Electrical tributaries				
17	SPIA-1E4/4B	140 Mbit/s or STM-1 electrical or STM-1 optical	3	6
	SIA-1/4B	STM-1 electrical or STM-1 optical		
17a	OI-S 1.1/2	Optical Interface Short Haul STM-1 1310 nm	2	

Table 8-10.

17b	PB-1E4/PW/ 2	working PB, 2 ch. for STM-1 and 140 Mbit/s	2	
17c	PB-1E4/PP/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s	2	
Electrical tributaries				
18	PI-E1/63	63 * 2 Mbit/s, 75 Ω	2	4
18a	PB-E1/75/32	Direct-through connect PB 75 Ω, 32 ch.		
18b	PB-E1/P75/ 32	Protection PB 75 Ω, 32 ch.	4	5
18c	PB-E1/120/ 32	75 to 120 Ω conversion PB, 32 ch.		
18d	PB-E1/ P120/32	75 to 120 Ω conversion PB, with protection, 32 ch.		
19	PI-E3DS3/ 6+6	6 * 45 Mbit/s and 6 * 34 Mbit/s		
20	PI-DS3/12	12 * 45 Mbit/s	2	
19, 20a	PB-E3DS3/6	Protection PB 34 / 45 Mbit/s, 6 ch.	2	
Additional timing circuit packs				
21	TI-DS2DS0/ 1	Timing Interface CP 64+8 kHz In/ 6312 kHz Out		
22	TI-I 1.1DS0/ 1	Timing Interface CP 64+8 kHz In/ 155.52 MHz Out		

Remarks:

1. If protection of the CC is not required, 1 x CC should be engineered.
2. If protection of the PT-stnd is not required, 1 x PT-stnd should be engineered. If a stability of 0.37 ppm for 24 hour is required, the PT-str3 should be engineered.
3. Depending on the optical power budget needed.
4. If protection of the 2 Mbit/s interfaces is not required, no additional PI-E1/ 63 should be engineered for protection.
5. If protection of the 2 Mbit/s interfaces is not required, no paddle board has to be engineered. It should be noted that if protection is required in future, it is advisable to install the direct-through connect paddle board 75 W, 32 ch paddle board as this will ease installation practice in future. If 120 W interfaces are needed, either 16 x PB-E1/120/32 (no 2 Mbit/s protection) or 16 x PB-E1/P120/32 (2 Mbit/s protection) should be engineered
6. STM-1 electrical and E4 units can be equipment protected at the same time by using a SPIA-1E4/4B in slot 4. The SPIA-1E4/4B automatically configures itself in the correct operation mode. Additionally in R4.0 it is possible to in-service upgrade an older E4 or STM-1e unit in a worker slot to a SPIA-1E4/4B or SIA-1/ 4B unit. A SPIA-1E4/4B or SIA-1/4B unit in a worker slot **can not be protected** by an older E4 or STM-1e unit in slot 4, even not when both units are running in the same mode.

WaveStar® ADM 16/1 Add/Drop Multiplexer STM-16 (High Order interfaces)

Table 8-11.

	Circuit Pack (CP) Name	Description	Number	Remark
Subracks				
1	EFA 4	High-density subrack	1	
Core circuit packs				
3	SC SC2	System Controller	1	
5	CC-64/32 CC-64/32B	Cross-Connect CP 64 x 64 HO, 32 x 32 LO	2	
7	PT-stnd	Power and Timing CP ± 4.6 ppm	2	2
8	PT-str3	Power and Timing CP ± 0.37 ppm		
Line-interface circuit packs				
9	SI-L 16.1/1C SI-L 16.1/1D	Long-haul 2.5 Gbit/s 1310 nm, L 16.1, ITU range		
10	SI-L 16.2/1C SI-L 16.2/1D	Long-haul 2.5 Gbit/s 1550 nm, L 16.2 , ITU range		
11	SI-L 16.3/1B	Long-haul 2.5 Gbit/s 1550 nm, L 16.3	2	3
13	SI-16EMLx/1	Interworking packs OLS 1.6T (80 different wavelengths)		
Boosters and pre-amplifier circuit packs				
14a	SI-EMLU16.2/1	EML 2.5 Gbit/s 1550 nm U 16.2		
14b	LPBA-U 16.2/3	Booster and Pre-Amplifier (160km)		
14c	LBA-V16.2/1	Booster (120km)		
Optical tributaries				
15	SA-0/12	Converter board STM-0		
15a	OI-0/6	Optical Interface STM-0 1310 nm		
16	SI-S 4.1/1	Short Haul, STM-4 1310 nm	3	
Optical / Electrical tributaries				
17	SPIA-1E4/4B	140 Mbit/s or STM-1 electrical or STM-1 optical	4	4
	SIA-1/4B	STM-1 electrical or STM-1 optical		
17a	OI-S 1.1/2	Optical Interface Short Haul STM-1 1310 nm	8	
17b	PB-1E4/PW/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		

Table 8-11.

17c	PB-1E4/PP/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		
Electrical tributaries				
18	PI-E1/63	63 * 2 Mbit/s, 75 Ω		
18a	PB-E1/75/32	Direct-through connect PB 75 Ω, 32 ch.		
18b	PB-E1/P75/ 32	Protection PB 75 Ω, 32 ch.		
18c	PB-E1/120/ 32	75 to 120 Ω conversion PB, 32 ch.		
18d	PB-E1/ P120/32	75 to 120 Ω conversion PB, with protection, 32 ch.		
19	PI-E3DS3/ 6+6	6 * 45 Mbit/s and 6 * 34 Mbit/s		
20	PI-DS3/12	12 * 45 Mbit/s		
19, 20a	PB-E3DS3/6	Protection PB 34 / 45 Mbit/s, 6 ch.		
Additional timing circuit packs				
21	TI-DS2DS0/ 1	Timing Interface CP 64+8 kHz In/ 6312 kHz Out		
22	TI-I 1.1DS0/ 1	Timing Interface CP 64+8 kHz In/ 155.52 MHz Out		

Remarks:

1. If protection of the CC is not required, 1 x CC should be engineered.
2. If protection of the PT-stnd is not required, 1 x PT-stnd should be engineered. If a stability of 0.37 ppm for 24 hour is required, the PT-str3 should be engineered.
3. Depending on the optical power budget needed.
4. STM-1 electrical and E4 units can be equipment protected at the same time by using a SPIA-1E4/4B in slot 4. The SPIA-1E4/4B automatically configures itself in the correct operation mode. Additionally in R4.0 it is possible to in-service upgrade an older E4 or STM-1e unit in a worker slot to a SPIA-1E4/4B or SIA-1/ 4B unit. A SPIA-1E4/4B or SIA-1/4B unit in a worker slot **can not be protected** by an older E4 or STM-1e unit in slot 4, even not when both units are running in the same mode.

WaveStar® ADM 16/1 Add/Drop Multiplexer STM-16 (Long distance rings, with LO grooming of 504 x 2 Mbit/s)

Table 8-12.

	Circuit Pack (CP) Name	Description	Number	Remark
Subracks				
1	EFA 4	High-density subrack	1	
Core circuit packs				
3	SC SC2	System Controller	1	
5	CC-64/32 CC-64-32B	Cross-Connect CP 64 x 64 HO, 32 x 32 LO	2	1
7	PT-stnd	Power and Timing CP ± 4.6 ppm	2	2
8	PT-str3	Power and Timing CP ± 0.37 ppm		
Line-interface circuit packs				
9	SI-L 16.1/1C SI-L 16.1/1D	Long-haul 2.5 Gbit/s 1310 nm, L 16.1, ITU range		
10	SI-L 16.2/1C SI-L 16.2/1D	Long-haul 2.5 Gbit/s 1550 nm, L 16.2 , ITU range		
11	SI-L 16.3/1B	Long-haul 2.5 Gbit/s 1550 nm, L 16.3	1	3
13	SI-16EMLx/1	Interworking packs OLS 1.6T (80 different wavelengths)		
Boosters and pre-amplifier circuit packs				
14a	SI-EMLU16.2/1	EML 2.5 Gbit/s 1550 nm U 16.2	1	3
14b	LPBA-U 16.2/3	Booster and Pre-Amplifier (160km)	1	3
14c	LBA-V16.2/1	Booster (120km)		
Optical tributaries				
15	SA-0/12	Converter board STM-0		
15a	OI-0/6	Optical Interface STM-0 1310 nm		
16	SI-S 4.1/1	Short Haul, STM-4 1310 nm		
Optical / Electrical tributaries				
17	SPIA-1E4/4B	140 Mbit/s or STM-1 electrical or STM-1 optical		
	SIA-1E4/4B	STM-1 electrical or STM-1 optical		
17a	OI-S 1.1/2	Optical Interface Short Haul STM-1 1310 nm		

Table 8-12.

17b	PB-1E4/PW/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		
17c	PB-1E4/PP/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		
Electrical tributaries				
18	PI-E1/63	63 * 2 Mbit/s, 75 Ω	9	4
18a	PB-E1/75/32	Direct-through connect PB 75 Ω, 32 ch.		
18b	PB-E1/P75/ 32	Protection PB 75 Ω, 32 ch.	18	5
18c	PB-E1/120/ 32	75 to 120 Ω conversion PB, 32 ch.		
18d	PB-E1/ P120/32	75 to 120 Ω conversion PB, with protection, 32 ch.		
19	PI-E3DS3/ 6+6	6 * 45 Mbit/s and 6 * 34 Mbit/s		
20	PI-DS3/12	12 * 45 Mbit/s		
19, 20a	PB-E3DS3/6	Protection PB 34 / 45 Mbit/s, 6 ch.		
Additional timing circuit packs				
21	TI-DS2DS0/ 1	Timing Interface CP 64+8 kHz In/ 6312 kHz Out		
22	TI-I 1.1DS0/ 1	Timing Interface CP 64+8 kHz In/ 155.52 MHz Out		

Remarks:

1. If protection of the CC is not required, 1 x CC should be engineered.
2. If protection of the PT-stnd is not required, 1 x PT-stnd should be engineered. If a stability of 0.37 ppm for 24 hour is required, the PT-str3 should be engineered.
3. Depending on the optical power budget needed.
4. If protection of the 2 Mbit/s interfaces is not required, no additional PI-E1/ 63 should be engineered for protection.
5. If protection of the 2 Mbit/s interfaces is not required, no paddle board has to be engineered. It should be noted that if protection is required in future, it is advisable to install the direct-through connect paddle board 75 W, 32 ch paddle board as this will ease installation practice in future. If 120 W interfaces are needed, either 16 x PB-E1/120/32 (no 2 Mbit/s protection) or 16 x PB-E1/P120/32 (2 Mbit/s protection) should be engineered

WaveStar® ADM 16/1 Add/Drop Multiplexer STM-16 (STM-1 and STM-4 ring-closure on tributaries)

Table 8-13.

	Circuit Pack (CP) Name	Description	Number	Remark
Subracks				
1	EFA 4	High-density subrack	1	
Core circuit packs				
3	SC SC2	System Controller	1	
5	CC-64/32 CC-64/32B	Cross-Connect CP 64 x 64 HO, 32 x 32 LO	2	1
7	PT-stnd	Power and Timing CP ± 4.6 ppm	2	2
8	PT-str3	Power and Timing CP ± 0.37 ppm		
Line-interface circuit packs				
9	SI-L 16.1/1C SI-L 16.1/1D	Long-haul 2.5 Gbit/s 1310 nm, L 16.1, ITU range	2	3
10	SI-L 16.2/1C SI-L 16.2/1D	Long-haul 2.5 Gbit/s 1550 nm, L 16.2 , ITU range		
13	SI-16EMLx/1	Interworking packs OLS 400G (80 different wavelengths)		
Boosters and pre-amplifier circuit packs				
14a	SI-EMLU16.2/1	EML 2.5 Gbit/s 1550 nm U 16.2		
14b	LPBA-U 16.2/3	Booster and Pre-Amplifier (160km)		
14c	LBA-V16.2/1	Booster (120km)		
Optical tributaries				
15	SA-0/12	Converter board STM-0		
15a	OI-0/6	Optical Interface STM-0 1310 nm		
16	SI-S 4.1/1	Short Haul, STM-4 1310 nm	2	
Optical / Electrical tributaries				
17	SPIA-1E4/4B	140 Mbit/s or STM-1 electrical or STM-1 optical	4	
	SIA-1/4B	STM-1 electrical or STM-1 optical		
17a	OI-S 1.1/2	Optical Interface Short Haul STM-1 1310 nm	8	
17b	PB-1E4/PW/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		
17c	PB-1E4/PP/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		

Table 8-13.

Electrical tributaries				
18	PI-E1/63	63 * 2 Mbit/s, 75 Ω		
18a	PB-E1/75/32	Direct-through connect PB 75 Ω, 32 ch.		
18b	PB-E1/P75/ 32	Protection PB 75 Ω, 32 ch.		
18c	PB-E1/120/ 32	75 to 120 Ω conversion PB, 32 ch.		
18d	PB-E1/ P120/32	75 to 120 Ω conversion PB, with protection, 32 ch.		
19	PI-E3DS3/ 6+6	6 * 45 Mbit/s and 6 * 34 Mbit/s		
20	PI-DS3/12	12 * 45 Mbit/s		
19, 20a	PB-E3DS3/6	Protection PB 34 / 45 Mbit/s, 6 ch.		
Additional timing circuit packs				
21	TI-DS2DS0/ 1	Timing Interface CP 64+8 kHz In/ 6312 kHz Out		
22	TI-I 1.1DS0/ 1	Timing Interface CP 64+8 kHz In/ 155.52 MHz Out		

Remarks:

1. If protection of the CC is not required, 1 x CC should be engineered.
2. If protection of the PT-stnd is not required, 1 x PT-stnd should be engineered. If a stability of 0.37 ppm for 24 hour is required, the PT-str3 should be engineered.
3. Depending on the optical power budget needed.

WaveStar® ADM 16/1; Japanese and United States of America uses

Table 8-14.

	Circuit Pack (CP) Name	Description	Number	Remark
Subracks				
1	EFA 4	High-density subrack	1	
Core circuit packs				
3	SC SC2	System Controller	1	
5	CC-64/32 CC-64/32B	Cross-Connect CP 64 x 64 HO, 32 x 32 LO	2	1
7	PT-stnd	Power and Timing CP ± 4.6 ppm		
8	PT-str3	Power and Timing CP ± 0.37 ppm	2	2
Line-interface circuit packs				
9	SI-L 16.1/1C SI-L 16.1/1D	Long-haul 2.5 Gbit/s 1310 nm, L 16.1, ITU range	1	3
10	SI-L 16.2/1C SI-L 16.2/1D	Long-haul 2.5 Gbit/s 1550 nm, L 16.2 , ITU range	1	3
13	SI-16EMLx/1	Interworking packs OLS 1.6T (80 different wavelengths)		
Boosters and pre-amplifier circuit packs				
14a	SI-EMLU16.2/1	EML 2.5 Gbit/s 1550 nm U 16.2		
14b	LPBA-U 16.2/3	Booster and Pre-Amplifier (160km)		
14c	LBA-V16.2/1	Booster (120km)		
Optical tributaries				
15	SA-0/12	Converter board STM-0	2	
15a	OI-0/6	Optical Interface STM-0 1310 nm	4	
16	SI-S 4.1/1	Short Haul, STM-4 1310 nm	2	
Optical / Electrical tributaries				
17	SPIA-1E4/4B	140 Mbit/s or STM-1 electrical or STM-1 optical	2	
	SIA-1/4B	STM-1 electrical or STM-1 optical		
17a	OI-S 1.1/2	Optical Interface Short Haul STM-1 1310 nm	4	
17b	PB-1E4/PW/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		
17c	PB-1E4/PP/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s		

Table 8-14.

Electrical tributaries				
18	PI-E1/63	63 * 2 Mbit/s, 75 Ω		
18a	PB-E1/75/32	Direct-through connect PB 75 Ω, 32 ch.		
18b	PB-E1/P75/ 32	Protection PB 75 Ω, 32 ch.		
18c	PB-E1/120/ 32	75 to 120 Ω conversion PB, 32 ch.		
18d	PB-E1/ P120/32	75 to 120 Ω conversion PB, with protection, 32 ch.		
19	PI-E3DS3/ 6+6	6 * 45 Mbit/s and 6 * 34 Mbit/s		
20	PI-DS3/12	12 * 45 Mbit/s	2	
19, 20a	PB-E3DS3/6	Protection PB 34 / 45 Mbit/s, 6 ch.	2	
Additional timing circuit packs				
21	TI-DS2DS0/ 1	Timing Interface CP 64+8 kHz In/ 6312 kHz Out	2	
22	TI-I 1.1DS0/ 1	Timing Interface CP 64+8 kHz In/ 155.52 MHz Out		

Remarks:

1. If protection of the CC is not required, 1 x CC should be engineered.
2. If protection of the PT-stnd is not required, 1 x PT-stnd should be engineered. If a stability of 0.37 ppm for 24 hour is required, the PT-str3 should be engineered.
3. Depending on the optical power budget needed.

WaveStar® ADM 16/1 Local Cross-Connect

Table 8-15.

	Circuit Pack (CP) Name	Description	Number	Remark
Subracks				
1	EFA 4	High-density subrack	1	
Core circuit packs				
3	SC SC2	System Controller	1	
5	CC-64/32 CC-64/32B	Cross-Connect CP 64 x 64 HO, 32 x 32 LO	2	1
7	PT-stnd	Power and Timing CP ± 4.6 ppm	2	2
8	PT-str3	Power and Timing CP ± 0.37 ppm		
Line-interface circuit packs				
9	SI-L 16.1/1C	Long-haul 2.5 Gbit/s 1310 nm, L 16.1, ITU range		3
10	SI-L 16.2/1C	Long-haul 2.5 Gbit/s 1550 nm, L 16.2 , ITU range		
13	SI-16EMLx/1	Interworking packs OLS 1.6T (80 different wavelengths)		
Boosters and pre-amplifier circuit packs				
14a	SI-EMLU16.2/1	EML 2.5 Gbit/s 1550 nm U 16.2		
14b	LPBA-U 16.2/3	Booster and Pre-Amplifier (160km)		
14c	LBA-V16.2/1	Booster (120km)		
Optical tributaries				
15	SA-0/12	Converter board STM-0		
15a	OI-0/6	Optical Interface STM-0 1310 nm		
16	SI-S 4.1/1	Short Haul, STM-4 1310 nm	2	
Optical / Electrical tributaries				
17	SPIA-1E4/4B	140 Mbit/s or STM-1 electrical or STM-1 optical	3	6
	SIA-1/4B	STM-1 electrical or STM-1 optical		
17a	OI-S 1.1/2	Optical Interface Short Haul STM-1 1310 nm	2	
17b	PB-1E4/PW/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s	2	
17c	PB-1E4/PP/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s	2	

Table 8-15.

Electrical tributaries				
18	PI-E1/63	63 * 2 Mbit/s, 75 Ω	2	4
18a	PB-E1/75/32	Direct-through connect PB 75 Ω, 32 ch.		
18b	PB-E1/P75/ 32	Protection PB 75 Ω, 32 ch.	4	5
18c	PB-E1/120/ 32	75 to 120 Ω conversion PB, 32 ch.		
18d	PB-E1/ P120/32	75 to 120 Ω conversion PB, with protection, 32 ch.		
19	PI-E3DS3/ 6+6	6 * 45 Mbit/s and 6 * 34 Mbit/s	2	
20	PI-DS3/12	12 * 45 Mbit/s		
19, 20a	PB-E3DS3/6	Protection PB 34 / 45 Mbit/s, 6 ch.	2	
Additional timing circuit packs				
21	TI-DS2DS0/ 1	Timing Interface CP 64+8 kHz In/ 6312 kHz Out		
22	TI-I 1.1DS0/ 1	Timing Interface CP 64+8 kHz In/ 155.52 MHz Out		

Remarks:

1. If protection of the CC is not required, 1 x CC should be engineered.
2. If protection of the PT-stnd is not required, 1 x PT-stnd should be engineered. If a stability of 0.37 ppm for 24 hour is required, the PT-str3 should be engineered.
3. No line port units are needed.
4. If protection of the 2 Mbit/s interfaces is not required, no additional PI-E1/ 63 should be engineered for protection.
5. If protection of the 2 Mbit/s interfaces is not required, no paddle board has to be engineered. It should be noted that if protection is required in future, it is advisable to install the direct-through connect paddle board 75 W, 32 ch paddle board as this will ease installation practice in future. If 120 W interfaces are needed, either 16 x PB-E1/120/32 (no 2 Mbit/s protection) or 16 x PB-E1/P120/32 (2 Mbit/s protection) should be engineered
6. STM-1 electrical and E4 units can be equipment protected at the same time by using a SPIA-1E4/4B in slot 4. The SPIA-1E4/4B automatically configures itself in the correct operation mode. Additionally in R4.0 it is possible to in-service upgrade an older E4 or STM-1e unit in a worker slot to a SPIA-1E4/4B or SIA-1/ 4B unit. A SPIA-1E4/4B or SIA-1/4B unit in a worker slot **can not be protected** by an older E4 or STM-1e unit in slot 4, even not when both units are running in the same mode.

WaveStar® ADM 16/1 DWDM Access Terminal STM-16 (OLS 1.6T, to be used with High Order Interfaces)

Table 8-16.

	Circuit Pack (CP) Name	Description	Number	Remark
Subracks				
1	EFA 4	High-density subrack	1	
Core circuit packs				
3	SC SC2	System Controller	1	
5	CC-64/32 CC-64/32B	Cross-Connect CP 64 x 64 HO, 32 x 32 LO		
7	PT-stnd	Power and Timing CP ± 4.6 ppm	2	2
8	PT-str3	Power and Timing CP ± 0.37 ppm		
Line-interface circuit packs				
9	SI-L 16.1/1C SI-L 16.1/1D	Long-haul 2.5 Gbit/s 1310 nm, L 16.1, ITU range		
10	SI-L 16.2/1C SI-L 16.2/1D	Long-haul 2.5 Gbit/s 1550 nm, L 16.2 , ITU range		
13	SI-16EMLx/1	Interworking packs OLS 1.6T (80 different wavelengths)	2	3
Boosters and pre-amplifier circuit packs				
14a	SI-EMLU16.2/1	EML 2.5 Gbit/s 1550 nm U 16.2		
14b	LPBA-U 16.2/3	Booster and Pre-Amplifier (160km)		
14c	LBA-V16.2/1	Booster (120km)		
Optical tributaries				
15	SA-0/12	Converter board STM-0		
15a	OI-0/6	Optical Interface STM-0 1310 nm		
16	SI-S 4.1/1	Short Haul, STM-4 1310 nm	2	
Optical / Electrical tributaries				
17	SPIA-1E4/4B	140 Mbit/s or STM-1 electrical or STM-1 optical	6	6
	SIA-1/4B	STM-1 electrical or STM-1 optical		
17a	OI-S 1.1/2	Optical Interface Short Haul STM-1 1310 nm	8	
17b	PB-1E4/PW/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s	2	

Table 8-16.

17c	PB-1E4/PP/ 2	Protect PB, 2 ch. for STM-1 and 140 Mbit/s	2	
Electrical tributaries				
18	PI-E1/63	63 * 2 Mbit/s, 75 Ω		4
18a	PB-E1/75/32	Direct-through connect PB 75 Ω, 32 ch.		
18b	PB-E1/P75/ 32	Protection PB 75 Ω, 32 ch.		5
18c	PB-E1/120/ 32	75 to 120 Ω conversion PB, 32 ch.		
18d	PB-E1/ P120/32	75 to 120 Ω conversion PB, with protection, 32 ch.		
19	PI-E3DS3/ 6+6	6 * 45 Mbit/s and 6 * 34 Mbit/s		
20	PI-DS3/12	12 * 45 Mbit/s		
19, 20a	PB-E3DS3/6	Protection PB 34 / 45 Mbit/s, 6 ch.		
Additional timing circuit packs				
21	TI-DS2DS0/ 1	Timing Interface CP 64+8 kHz In/ 6312 kHz Out		
22	TI-I 1.1DS0/ 1	Timing Interface CP 64+8 kHz In/ 155.52 MHz Out		

Remarks:

1. If protection of the CC is not required, 1 x CC should be engineered.
2. If protection of the PT-stnd is not required, 1 x PT-stnd should be engineered. If a stability of 0.37 ppm for 24 hour is required, the PT-str3 should be engineered.
3. Depending on the wavelength and the numerous of STM-16 EML entrances.
4. If protection of the 2 Mbit/s interfaces is not required, no additional PI-E1/ 63 should be engineered for protection.
5. If protection of the 2 Mbit/s interfaces is not required, no paddle board has to be engineered. It should be d that if protection is required in future, it is advisable to install the direct-through connect paddle board 75 W, 32 ch paddle board as this will ease installation practice in future. If 120 W interfaces are needed, either 16 x PB-E1/120/32 (no 2 Mbit/s protection) or 16 x PB-E1/P120/32 (2 Mbit/s protection) should be engineered
6. STM-1 electrical and E4 units can be equipment protected at the same time by using a SPIA-1E4/4B in slot 4. The SPIA-1E4/4B automatically configures itself in the correct operation mode. Additionally in R4.0 it is possible to in-service upgrade an older E4 or STM-1e unit in a worker slot to a SPIA-1E4/4B or SIA-1/ 4B unit. A SPIA-1E4/4B or SIA-1/4B unit in a worker slot **can not be protected** by an older E4 or STM-1e unit in slot 4, even not when both units are running in the same mode.

Technical Data

9

Overview

This chapter contains the technical specifications of the WaveStar® ADM 16/1 Multiplexer and Transport System.

Optical interfaces

The optical interfaces of the WaveStar® ADM 16/1 have the following optical outputs and line codes.

Table 9-1. Optical interfaces

	STM-0	**STM-1**	**STM-4**	**STM-16**
Optical output	51.84 Mbit/s	155.52 Mbit/s	622.08 Mbit/s	2.488 Gbit/s
Optical line code	Scrambled non-return to zero, (NRZ)	Scrambled non-return to zero, (NRZ)	Scrambled non-return to zero, (NRZ)	Scrambled non-return to zero, (NRZ)

Electrical interfaces

The electrical interfaces of the WaveStar® ADM 16/1 have the following technical specifications.

Table 9-2. Electrical interfaces

	1.5 Mbit/s	**2 Mbit/s**	**34 Mbit/s**
Nominal bitrate	1544 kbit/s	2048 kbit/s	34.368 Mbit/s
Line code	AMI (G.703)	HDB3 (G.703)	HDB3 (G.703)
Insertion loss	acc. G.703	acc. G.703	acc. G.703
Return loss	acc. G.703	acc. G.703	acc. G.703
	45 Mbit/s	**140 Mbit/s**	**STM-1**
Nominal bitrate	44.736 Mbit/s	139.264 Mbit/s	155.520 Mbit/s
Line code	B3ZS (ANSI T1.102-1987).	CMI (G.703)	CMI (G.703)
Insertion loss	acc. G.703	acc. G.703	acc. G.703
Return loss	acc. G.703	acc. G.703	acc. G.703

The amplitude/shape of the DS1 output signal can be provisioned to match the cable between the WaveStar® ADM 16/1and the DDF, in such a way that the pulse shape at the DDF, which can be up to 655 feet away, meets the specification. Five signal levels can be provisioned in the transmitter, covering cable lengths between 0-131, 131-262, 262-393, 393-542 and 542-655 feet. The receiver has an automatic line build-out capability to handle cable lengths between 0-655 feet. These lengths assume 22 AWG ABAM type cable with an approximate $\sqrt{f}$ transfer and an attenuation of 5.5 dB and a phase rotation of 30° at a frequency of 772 kHz.

The amplitude/shape of the DS3 output signal can be provisioned to match the cable between the WaveStar® ADM 16/1and the DDF, in such a way that the pulse shape at the DDF, which can be up to 450 feet away, meets the specification.Two signal levels can be provisioned in the transmitter, covering cable lengths between 0-120 and 120-450 feet. The receiver has an automatic line build-out capability to handle cable lengths between 0-450 feet. These lengths assume type 728 cable (Telcordia GR-139-CORE) with an approximate $\sqrt{f}$ transfer and an attenuation of 5.7 dB and a phase rotation of 38° at a frequency of 22.368 MHz.

Optical connector interface

All STM-4 and STM-16 optical packs are equipped with a universal built-out optical connector type, allowing the connector type to FC/PC or SC to be changed on-site depending on the customer needs.

The STM-1 optical circuit packs do have a SC-connection with a conversion possibility to FC/PC.

The STM-0 does have a LC-connection with a conversion possibility to FC/PC or SC.

Optical source and detector

The optical sources and detectors of the WaveStar® ADM 16/1 have the following technical specifications

Table 9-3.

Optical circuit pack type	Laser type	Optical detector	Hazard level IEC-60825-2:
STM-0 1310 nm	FP (MLM)	PIN	1
S-1.1 1310 nm	FP (MLM)	PIN	1
L-1.2 1550 nm	DFB (SLM)	PIN	1
S-4.1 1310 nm	FP (MLM)	PIN	1
L 4.2 1550 nm	DFB (SLM)	PIN	1
L-16.1 ITU 1310 nm	DFB (SLM)	APD	1
L-16.2/3 standard ITU 1550 nm	DFB (SLM)	APD	1
16 EMLx/1 (x from 9190 to 9585)	EML (SLM)	APD	1
U-16.2 1550 nm	EML	APD	3A
V-16.2 1550 nm	DFB (SLM)	APD	

MLM - Multi longitudinal mode

SLM - Single longitudinal mode

EML - External modulated laser

DFB - Distributed feedback laser (=SLM)

FP - Fabry-Perot (=MLM)

APD - Avalanche photodiode

Optical safety

The system is classified and labelled as specified in IEC 60825-1 and IEC 60825-2 “Radiation safety of laser products equipment, classification, requirements and users guide”. All parts of the equipment are designed to operate and be capable of being maintained without hazard to personnel from optical radiation.

The WaveStar® ADM 16/1 System includes an automatic power shutdown and restart (APSD) for the optical interworking pack with a booster/pre-amplifier facility to prevent hazard to personnel from optical radiation, as specified in ITU-T Recommendation G.664.

Optical power budgets

The WaveStar® ADM 16/1 Multiplexer and Transport System is designed to meet the optical power-budget specifications indicated in the following tables. These specifications are compliant with G.707, G.957, G.958 and G.691. For special application and to avoid overload if very short distances are being bridged, optical line build outs (10 dB) are available at the send side (see installation manual).

STM-0 / STM-1/STM-4

Table 9-4.

APPLICATION	unit	STM-0	S-1.1	S-4.1	L-1.2	L-4.2
Transmitter at Reference point S:						
Wavelength range	nm	1270-1360	1270-1360	1283-1345	1535-1565	1535-1565
- max	dBm	-11	-8	-8	0	+2
- min	dBm	-17	-15	-15	-5	-3
minimum extinction ratio	dB	11	8.2	8.2	10	10
Optical Patch between S and R:						
attenuation range	dB	0-10	0-12	0-12	10-28	10-24
maximum dispersion	ps/nm	N.A.	185	88	N.A.	2000
worst-case dispersion limited section length	km	N.A.	35	22	Section is not dispersion limited	Section is not dispersion limited
Receiver at Reference point R:						
Minimum sensitivity (BER ≤ 10^{-10})	dBm	-28	-28	-28	-34	-28
Minimum overload level	dBm	-8	-8	-8	-10	-8
Maximum optical path penalty	dB	1	1	1	1	1

STM-16

Table 9-5.

APPLICATION	unit	SI-L 16.1/ 1C(1D) ITU	SI-L 16.2/1C(1D) ITU
Transmitter at Reference point: S			
Wavelength range	nm	1280-1335	1535-1565
Spectral characteristics			
Maximum -20 dB width	nm	1	<1
Minimum side mode suppression ratio	dB	30	30
Mean launched power:			
- Max	dBm	+2	+2
- Min	dBm	-2	-2
Minimum extinction ratio	dB	8.2	8.2
Optical patch between S and R:			
Attenuation range (G.652)@ BER= 10^{-10}	dB	10-24	11-24 (L16.2)
Attenuation range (G.653)@ BER= 10^{-10}	dB	N.A.	11-25 (L16.3)
Maximum dispersion	ps/nm	230	1800
Maximum return loss of cable plant at S	dB	24	24
Maximum discrete reflectance between S&R	dBm	-27	-27
Worst-case dispersion limited section length (G.652 / G.653 fiber)	km	53	G.652: 90 G.653: Section is not dispersion limited.
Receiver at Reference point R:			
Minimum sensitivity (BER $\leq 10^{-10}$)	dBm	-27	-28
Minimum overload level	dBm	-8	-8
Maximum optical path penalty (G.652/653)	dB	1	G.652: 2 G.653: 1
Maximum reflectance at R	dB	-27	-27

All values are End Of Life (EOL)

1000BASE-X

Table 9-6.

APPLICATION	unit	1000BASE-SX	1000BASE-LX
Transmitter at Reference point S:			
Wavelength range	nm	850	1310
- max	dBm	tbd	tbd
- min	dBm	tbd	tbd
minimum extinction ratio	dB	tbd	tbd
Optical Patch between S and R:			
attenuation range	dB	tbd	tbd
maximum dispersion	ps/ nm	tbd	tbd
worst-case dispersion limited section length	km	tbd	tbd
Receiver at Reference point R:			
Minimum sensitivity (BER $\leq 10^{-10}$)	dBm	tbd	tbd
Minimum overload level	dBm	tbd	tbd
Maximum optical path penalty	dB	tbd	tbd

Booster, Booster/Pre-Amplifier and OLS 1.6T:

Table 9-7.

APPLICATION	unit	SI-EMLU 16.2/1+ LBPA U-16.2/1	SI-EMLU 16.2/1+ LBA V-16.2/1	SI-16EML x/1
Transmitter at Reference point S:				
Wavelength range	nm	1552.52	1535-1560	1530-1565
Mean launched power:				
- max	dBm	+15	+ 15	-3.8 (EOL) -4.6 (BOL)
- min	dBm	+12	+12	-6.2 (EOL) -5.4 (BOL)
Minimum extinction ratio	dB	8.2	8.2	13
Optical patch between S and R:				
Attenuation range (G.652)@ BER= 10^{-12}	dB	33 - 44	23-36	N.A.
Attenuation range (G.653)@ BER= 10^{-12}	dB	33 - 45	23-37	N.A.
Maximum dispersion	ps/nm	3200	2400	9600
Worst-case dispersion limited section length	km	160	120	N.A.
Receiver at Reference point R:				
Minimum sensitivity (BER $\leq 10^{-12}$)	dBm	-34	-26	N.A.
Minimum overload level	dBm	-18	-8	N.A.
Maximum optical path penalty	dB	2/1	2/1	2
Minimum optical signal to noise ratio (OSNR)		N.A.	N.A.	12.5 (over -24 to -10 dBm input power)

Power specification

Table 9-8.

Voltage range, all components	-48 to -60 V Battery voltages, CEPT T/TR02-02 (-40.5 V minimum, -72 V maximum)
Power feeders	Two power feeders

Table 9-9.

Configuration	**Power Dissipation**
WaveStar® ADM 16/1	450 - 600 Watt

Table 9-10.

Unit Name	**Unit type**	**Consumed Power (worst case) (Watt)**
General units		
Power and Timing ± 4.6 ppm	PT-stnd	15
Power and Timing ± 0.37 ppm	PT-str3	16
System Controller	SC	31
	SC2	26
Cross-connect 64/32	CC-64/32	57.6
	CC-64/32B	45
Fixed cross-connect	CC-fixed	2.15
Optical booster and pre-amplifier		
Optical Booster and Pre - Amplifier	LBPA-U 16.2/1	19.2
Optical Booster	LBA-V 16.2/1	11.2
Interworking pack for LBPA and LBA application	SI-EMLU 16.2/1	37.6
Optical interfaces		
STM-16 LH, 1310 nm	SI-L 16.1/1C	36.4
STM-16 LH, 1310 nm	SI-L 16.1/1D	22
STM-16 LH, 1550 nm	SI-L 16.2/1C	36.4
STM-16 LH, 1550 nm	SI-L 16.2/1D	22
STM- 16 LH, 1550 nm	SI-L 16.2/1+4dB	36.4
STM- 16 LH, 1550 nm	SI-L 16.3/1B	22
STM- 4 LH, 1550 nm	SI-L 4.2/1	8.5
STM- 4 SH, 1310 nm	SI-S 4.1/1	8.5
STM-16 interworking with the OLS 80G	SI-EML80.x/1	39.6

Table 9-10.

STM-16 interworking with the OLS 1.6T	SI-16EMLx/1	39.6
Gigabit Ethernet, optical interface	IP-GE/2	41.9
Optical paddle boards		
STM-1, optical interface	OI-L1.2/2	2.36
STM-1, optical interface	OI-S1.1/2 SC	3.5
STM-0, optical interface, SH 1310nm	OI-0/6	1.5
Electrical interfaces		
STM-1e/140 Mbit/s electrical	SPIA-1E4/4B	22
STM-0/AU-3 to TU-3	SA-0/12	41.7
STM-1	SIA-1/4B	22
2 Mbit/s	PI-E1/63	24
34/45 Mbit/s	PI-E3DS3/6+6	41.8
45 Mbit/s	PI-DS3/12	42.3
140 Mbit/s	PI-E4/4	21.2
10/100 Mbit/s Base-T	IP-LAN/8	16.7
10/100 Mbit/s Base-T	IP-LAN 8 Tlan+	42.4
Miscellaneous		
Fans	-	15

Dimensions

The subracks for the WaveStar® ADM 16/1 Multiplexer and Transport System are compliant with the engineering requirements for subracks mounted in miscellaneous racks and cabinets described in ETSI 300 119-4 for wide racks (600x600 mm). The WaveStar® ADM 16/1 Multiplexer and Transport System is housed in a 500 mm wide construction (required rack depth 600 mm).

Based on the above requirements, the WaveStar® ADM 16/1 outside subrack dimensions are:

Table 9-11.

Subrack type	**D x W x H**
WaveStar® ADM 16/1 High Density EFA4	545 x 500 x 750 mm

System weight

Table 9-12.

System configuration	Weight
WaveStar® ADM 16/1 max configuration	less then 70 kg (including internal cables)

Electrical connectors

- All transmission interfaces are connected to the backplane METRAL™ connector system
- All non-transmission interfaces are connected via Sub-D type connectors via the integrated interconnection Panel (ICP).

Environmental specifications

Table 9-13.

Climatic Conditions	Temperature range	Humidity	ETSI Class
Environment	-5... +45° C	3 - 90% (NC)	3.1e
Storage	-25... +55 C	up to 100%(NC)	1.2
Transport	-40... +70 C	up to 95% (NC)	2.3

NC = Non-condensing

The WaveStar® ADM 16/1 Multiplexer and Transport System mounted in a 2000 mm rack comply with earthquake proof: zone 4 (modified Mercalli scale > 9) requirements as per IEC721-2-6.

The WaveStar® ADM 16/1 Multiplexer and Transport System fulfills the requirements as specified in ETSI 300 386-1; Public Telecommunication Network Equipment -EMC/ESD requirements as also indicated in the table below.

Table 9-14.

Radiated emission	EN 55 022 Class B
Conducted emission:	
AC power	EN 55 022 Class B
DC power	EN 55 022/ETS 300 386-1
Telecom ports	CISPR 22 Class B
	IEC 1000-4-2 level 4
Electrostatic discharge:	EN 61000-4-2 level 4
Radiated immunity:	IEC 1000-4-3 level 3
Electrical fast transient:	
AC power	IEC 1000-4-4 level 3
DC power	IEC 1000-4-4 level 3
Telecom ports	IEC 1000-4-4 level 3

Table 9-14.

Surges:	
AC power	IEC 1000-4-5 level 4
Indoor telecom port	ETS 300 386-1
Continuous wave:	
AC power	IEC 1000-4-6 level 2
DC power	IEC 1000-4-6 level 2
Telecom ports	IEC 1000-4-6 level 2

General ITU recommendations

The WaveStar® ADM 16/1 is in compliance with the

- General ITU Recommendations: G.707
- Equipment Recommendations: G.781, G.782, G.783, G.784, G.813
- Physical interface Recommendations: G.957 and G.691 for optical and G.703 for electrical interfaces.
- Performance requirements: G.823, G.825, G.826
- Optical safety requirements: G.664

Mapping structure

The following mapping structures are supported:

Between cross-connect and line/tributary interface, SDH mappings:

- AU-4-4c <-> AUG4 <-> AUG16 <-> STM-16
- AU-4 <-> AUG1 <-> AUG4 <-> AUG16 <-> STM-16
- AU-4-4c <-> AUG4 <-> STM-4
- AU-4 <-> AUG1 <-> AUG4 <-> STM-4
- AU-4 <-> AUG1 <-> STM-1
- AU-4 <-> VC-4 <-> E4
- AU-4 <-> VC-4 <-> TUG-3 <-> TU-3 <-> VC-3 <-> E3/DS3
- AU-4 <-> VC-4 <-> TUG-3 <-> TUG-2 <-> TU-12 <-> VC-12 <-> E1
- AU-4 <-> VC-4 <-> TUG-3 <-> TUG-2 <-> TU-12 <-> VC-11 <-> DS1

Between cross-connect and tributary interface, with conversion from TU-3 to AU-3:

- AU-4 <-> VC-4 <-> TUG-3 <-> TU-3 <-> VC-3 <->AU-3 <-> STM-4 (OC-12)
- AU-4 <-> VC-4 <-> TUG-3 <-> TU-3 <-> VC-3 <->AU-3 <-> STM-1 (OC-3)
- AU-4 <-> VC-4 <-> TUG-3 <-> TU-3 <-> VC-3 <->AU-3 <-> STM-0

Between cross-connect and tributary interface, Ethernet mapping on LJB458 TransLAN unit:

- AU-4 <-> VC-4 <-> TUG-3 <-> TUG-2 <-> n x TU-12 <-> n x VC-12 <-> nxE1 <-> ML PPP <-> Ethernet

Between cross-connect and tributary interface, Ethernet mapping on LJB459 TransLAN unit:

- AU-4 <-> VC-4 <-> VC-3-Xv <-> EOS <-> Ethernet
- AU-4 <-> VC-4 <-> TUG-3 <-> VC-12-Xv <-> Ethernet

Between cross-connect and tributary interface, GbE Ethernet mapping on LJB460 GbE unit:

- WAN <-> T1X1.5/99-268 (EOS) protocol <-> VC-3-gv <-> g x TU-3 <-> VC-4 (g=1,2) or
- WAN <-> T1X1.5/2001-024r4 (ITU-T G.7041, GFP) protocol <-> C3-Xc <-> VC-3-Xv <-> X * VC-3 (X=1,2)
- 1000BaseX <-> T1X1.5/2001-024r4 (ITU-T G.7041, GFP) protocol <-> C4-Xc <-> VC-4-Xv <-> X * VC-4 (X=1,.., 4)

Support of different size (ss)-bit support on STM-1/4/16 interfaces (new standards):

- In the source direction, the transmitted ss-bits can be provisioned in '10' (SDH mode, default) or '00' (SONET mode)
- In the sink direction the incoming ss bits are ignored.

Electrical interfaces

The following electrical interfaces are available:

- 1.5 Mbit/s asynchronous/byte synchronous, 63 interfaces per circuit pack
- 2 Mbit/s asynchronous/byte synchronous, 63 interfaces per circuit pack
- 34 and 45 Mbit/s asynchronous, 6 interfaces each per circuit pack
- 45 Mbit/s asynchronous, 12 interfaces per circuit pack
- 140 Mbit/s asynchronous, 4 interfaces per circuit pack
- STM-1 electrical intra-station, 4 interfaces per circuit pack.
- Ethernet/LAN, 8 interfaces per circuit pack

Operations system interfaces

- Office alarms

  The steady state current for office alarms connections should not exceed 0.9 A at 60 V or 1.8 A at 30 V. The maximum transient currents (20 msec duration) during initial contact closure should not exceed 9 A at 60 V or 18 A at 30 V.

- Miscellaneous discrete inputs:

  Any external equipment to be monitored must provide the electrical equivalent of a contact closure across the corresponding pairs. The contact closure must be capable of passing at least 10 mA of drive current, voltage specifications are CMOS compatible.

  There are eight miscellaneous discrete input points for all WaveStar® ADM 16/1 configurations.

- Miscellaneous discrete outputs:

  All WaveStar® ADM 16/1 configurations provide four miscellaneous discrete output: hard contacts, contact rating 60V/0.5 A.

Customer data interfaces

The system supports 4 interfaces for customer access to user bytes, 2 interfaces are according G.703, 2 interfaces are according V.11. The user can select six of the following 64 kbit/s OH-channels to be routed to the connector points:

- Engineering order wire E1 or E2, 64 kbit/s

  The WaveStar® ADM 16/1 offers external access to the E1 or E2 bytes for all STM-1, STM-4 and STM-16 interfaces. Access is via a connector on the interconnection panel.

- User channels F1, 64 kbit/s

  The WaveStar® ADM 16/1 offers external access to the section user channel F1 byte for all STM-1, STM-4 and STM-16 interfaces. Access is via a connector on the interconnection panel.

- National Use bytes, RS-NU and MS-NU, 64 kbit/s

  The WaveStar® ADM 16/1 offers external access to the section user channel RS-NU and MS-NU byte of STM-1#1 for all STM-1, STM-4 and STM-16 interfaces. Access is via a connector on the interconnection panel.

NOTE:
RS-NU and MS-NU access on STM-16 requires the new STM-16 units LJB435-LJB436 (SI-L16.1/1D and SI-L16.2/1D).

Ethernet Interfaces

- Electrical 10/100Base-T Ethernet interfaces according to IEEE 802.3, 2000 edition with configurable auto-negotiation function.
- Multilink PPP on LJB458 unit according to RFC 1990.
- EOS mapping on LJB459 according to T1X1.5/99-268 protocol.
- LAN promiscuous mode according to RFC 1638.
- Ethernet bridging according to IEEE 802.1D
- VPN/Customer VLAN tagging or IEEE 802.1Q compliant VLAN Tagging
- GARP VLAN Registration Protocol (GVRP) according to IEEE 802.1Q Clause 11
- IEEE 802.1p QoS

Timing and network synchronization

Table 9-15. Timing modes

System	Free running	Holdover mode	Locked mode with reference
WaveStar® ADM 16/1, all configurations	÷	÷	- one of the external sync. inputs - one of the 2 Mbit/s tributary inputs - one of the STM-N inputs

Two types of timing packs are available:

- Built-in oscillator standard, accuracy 4.6 ppm according G.813 option 1
- Built-in oscillator stratum-3, accuracy 4.6 ppm according G.813 option 1, stability 0.37 ppm first 24 hours.

Support of the ETSI synchronization status message algorithms.

Two programmable input/output station clock interfaces: 2048 kHz (G703.10) or 2048 kbit/s (G703.6, 75 or 120 Ω)

Timing Reference

- Timing generator (± 4.6 ppm or ± 0.37 ppm)
- Phase and frequency continuity at timing source switch-over
- Automatic timing reference protection switching
- Timing generator with hold-over

Pointer Justification Event Counter

The following parameters are available to estimate the synchronization performance:

- PJE-: Count of negative pointer justifications
- PJE+: Count of positive pointer justifications

Both counters are present on one outgoing AU-4 pointer generation circuit per outgoing STM-N.

Transmission performance

- Jitter on STM-N interfaces G.813/G.825
- Jitter on PDH interfaces G.823/G.783
- Error performance G.826
- Performance monitoring G.784/G.826

Performance monitoring

The WaveStar® ADM 16/1 has Performance Monitoring capabilities at the following termination points. These points depend on the actual hardware configuration of the WaveStar® ADM 16/1.

Termination points	Equipment
VC-12 TTP/CTP	for each of the 2 Mbit/s ports
VC-3 TTP/CTP	for each of the 34 or 45 Mbit/s ports
VC-4 TTP/CTP	for each of the 140 Mbit/s ports and terminated VC-4s in the cross connects
RS-16	for each of the 2.488 Gbit/s ports
MS-16	for each of the 2.488 Gbit/s ports
MS-4	for each of the 622 Mbit/s ports
MS-1	for each of the155 Mbit/s ports.

NOTE:
Performance monitoring on VC-12 CTPs and VC-3 CTPs requires the CC-64/32B (LJB434) cross-connect unit.

The following number of bins are available for the WaveStar™ ADM 16/1:

Interval	History bins	Total History bin storage time
15 minute	16	4 hours
24 hour	1	1 day

A threshold can be set for these counts.

The following features are also available for performance monitoring:

- Unavailable period registering
- Severity settings for alarms on each termination point instance.

In releases up to Ruby release 250 performance monitoring points are supported.

With Ruby software, Ruby controller hardware (LJB457B) and Ruby Cross-connect-64/32 (LJB434) 600 performance monitor points are supported simultaneously.

With Pearl software, Ruby controller hardware (LJB457B) and Ruby Cross-connect-64/32 (LJB434) 1200 performance monitor points are supported simultaneously.

2 Mbit/s non-intrusive monitoring, AIS detection

- It is possible to monitor the CRC-4, E-bit and A-bit information in TS0 of any 2 Mbit/s in both directions for performance monitoring purposes for G.704 structured 2 Mbit/s tributaries.

Performance Monitoring for LAN ports

On the VC3/VC12 termination points that are connected to a WAN port, the "normal" performance monitoring can be activated. The same counters that apply for VC3/ VC12TPs on any other port also apply to the VC3/VC12 TP's on a WAN port.

Apart from this standard SDH PM, a limited amount of counters that are dedicated to LAN/WAN ports are defined. Activation of these counters can be established by setting the LAN port mode to monitored, selecting a LAN port or WAN port as active PM point, and setting the PM point type to LAN or WAN.

The supported dedicated parameters are:

- CbS (total number of bytes sent)
- CbR (total number of bytes received)
- pDe (packets in error dropped)

Note that CbS and CbR are rather traffic monitoring counters than performance monitoring counters, as they give insight in the traffic load in all places in the network. pDe is a real performance monitoring counter as it gives an indication about the performance of the network. Only unidirectional PM is supported for these parameters. See Figure 5-2 for the location of the measurements. Note that because of the difference in units, bytes versus packets, the counters cannot be correlated with each other. Also the counter for dropped packets considers only packets dropped due to errors, and does not include packets dropped due to congestion.

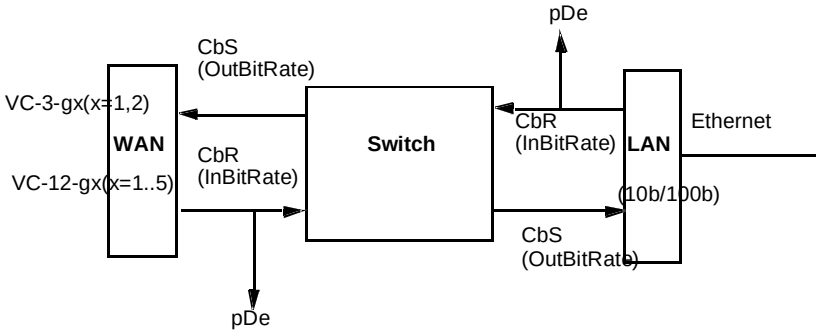


Figure 9-1. Performance Monitoring Counters

Performance Monitoring on LAN connections (Gigabit Ethernet ports)

It is possible to monitor byte and packet related performance parameters on any external Ethernet port and any internal port linked with VC-3/4-Xv channels. The following counters are supported for each port :

- Outgoing number of bytes
- Incoming number of bytes
- Number of incoming packets dropped

Accumulation of counts in 15 min and 24 hour bins can be selected per port. Recent bins are stored : 16 recent 15 min bins and 1 recent 24 hours bin. Thresholding (TR/RTR) on counts of dropped incoming packets can be enabled and configured per port.

Network element configurations

The WaveStar® ADM 16/1 system can be configured in the following ways:

- STM-16 0x1 and 1+1 End Terminal
- STM-16 2-fiber Add/Drop Terminal
- STM-16 0:1 or 0:2 Terminal
- Local cross-connect

OAM&P

- Installation self test
- Auto recovery after input power failure
- Local operations and maintenance via faceplate LEDs, buttons on the SC, user panel, F-interfaces
- Centralized operations and maintenance via Q-interface
- Software downloading via Q and F-interfaces, DCC link
- Alarm categories for indication of alarm severity and station alarm interface (9x)
- Local workstation (ITM-CIT)
- 8 x Miscellaneous discrete inputs and 4 outputs.

Network management

The WaveStar® ADM 16/1 can be managed with the following systems:

- Fully manageable by Navis™ Optical Management Solution
- Local workstation (ITM-CIT) via J45 connections, V.10 (RS-232 compatible)/F-interface
- Access to ECCs via in-station Q-LAN interface, G.773-CLNS1/10-Base-T* and 10-Base-2† Interfaces

* 10BASE-T: Twisted Pair Ethernet
† 10BASE-2: thin Ethernet or CheaperNet (coax cable)

Bandwidth management

- System capacity: 504 x 1.5 Mbit/s, 504 x 2 Mbit/s, 48 x 34 Mbit/s, 96 x 45 Mbit/s, 64 x 10/100Base-T LAN, 18x GbE, 96 x STM-0, 32 x 140 Mbit/s, 32 x STM-1 or 8 x STM-4
- Complete VC-4 cross-connecting
- Bi-directional cross-connecting
- Higher order and lower order broadcast functionality
- Protection access on MS-SPRing
- Higher order cross-connect size 64 x 64 VC-4
- Lower order cross-connect ranges up to 32 x 32 equivalents, that is 2016 x 2016 VC-12s or 96 x 96 VC-3s.

Protection and redundancy

- Tributary level redundancy:
  - 1: N equipment protection on 1.5 and 2 Mbit/s interface circuit packs (N_{max} = 8)
  - 1+1 equipment protection on 34/45 Mbit/s Interface circuit packs
  - 1:N equipment protection on 140 Mbit/s and STM1e interface circuit packs (N_{max}=4)
  - 1+1 equipment protection on cross-connect circuit pack and power and timing circuit pack)
- Non- revertive SNCP/N protection on VC-12/VC-3/VC-4 level according to G.841/Clause 8.
- Programmable hold-off times
- STM-0 optical interface circuit packs support 1+1 MSP according to G.841 annex B.
- STM-1 and STM-4 optical interface circuit packs support 1+1 MSP according to G.841 annex B, G.841 Clause 7.1/ETS 300417-3-1, ANSI T1.105 and Telcordia GR-253-CORE.
- STM-16 optical interface circuit packs support 1+1 MSP according to G.841/ Clause 7.1/ETS 300417-3-1.
- MS-SPRing in two fiber ring add/drop applications
- Selective MS-SPRing. In 2-fiber add/drop ring applications, the VC-4(-4c)'s in the ring can be protected by the MS-SPRing algorithm according to G.841 and ETS 300417. The user has the option to determine for each VC-4(-4c) individually, whether or not it participates in the MS-SPRing scheme. If an individual VC-4(-4c) does not participate then it can be either VC-4(-4c) SNC protected or not protected at all.
- Dual node interworking:
  - with drop and continue between SNCP and MS-SPRing on two nodes
  - with drop and continue between two MS-SPRings
  - to support VC-4 concatenation
- Maximum of 50 msec switching time for all protection mechanisms mentioned above
- Rapid Spanning Tree Protocol according IEEE 802.1w/D10
- LCAS for Ethernet (1000BASE-X "lite"): The implementation is base on Nortel/ Lucent contribution to T1X1.5/2000-199r1 (T1X1 T1.105 Section 7.3.4).

Overhead bytes processing

Regenerator Section Overhead Byte Usage

Table 9-16.

RSOH bytes	Function	STM-0 optical inter-station	STM-0 optical intra-station	STM-1 optical inter-station	STM-1 electrical intra-station
A1, A2	Framing	X	X	X	X
J0	Trace identifier byte	X	X	X	X
Z0	Spare bytes, for future international standardization				
B1	BIP-8 on RS (transmit only)	X	X	X	X
D1-D3	Data communication channel (DCC)	X	X	X	X
E1 #	OW channel	X		X	
F1 #	User channel	X		X	

Table 9-17.

RSOH bytes	Function	STM-4	STM-16
A1, A2	Framing	X	X
J0	Trace identifier byte	X	X
Z0	Spare bytes, for future international standardization	X	X
B1	BIP-8 on RS (transmit only)	X	X
E1 #	OW channel	X	X
F1 #	User channel	X	X
D1-D3	Data communication channel (DCC)	X	X
RS-NU (STM-1#1)	National usage	X	X

X=Supported

Multiplex Section overhead byte usage

Table 9-18.

MSOH bytes	Function	STM-0 optical inter-station	STM-0 optical intra-station	STM-1 optical inter-station	STM-1 electrical intra-station
B2	BIP-8 (STM-0)/ BIP-24 (STM-1) on MS	X	X	X	X
K1, K2 (bits 1-5)	Automatic protection switch (APS) channel	X	X	X	X
K2 (bits 6-8)	MS AIS/RDI Indicator	X	X	X	X
D4-D12	Data communication channel (DCC)	X	X	X	X
S1 (bits 5-8)	Synchronization status message	X	X	X	X
M1	REI (remote error indication) byte, transmit only	X	X	X	X
E2 #	Order wire channel	X		X	

Table 9-19.

MSOH bytes	Function	STM-4	STM-16
B2	BIP-N*24 on MS	X	X
K1, K2(bits 1-5)	Automatic protection switch	X	X
K2(bits 6-8)	MS AIS/RDI Indicator	X	X
D4-D12	Data communication channel (DCC)	X	X
S1 (bits 5-8)	Synchronization status message	X	X
M1	REI (remote error indication) byte, transmit only	X	X
E2 #	Order wire channel	X	X
MS-NU (STM-1#1)	National usage	X	X

X=Supported

Path Overhead Bytes VC-3/4/4-4c

Table 9-20.

VC-3/4/4-4c POH Byte	Function	140 Mbit/s Unit	CCU
J1	Path trace identifier byte	X	X
B3	BIP-8	X	X
C2	Signal label	X	X
G1	REI/RDI (transmit only)	X	X
F2	User channel	X	X
H4	Multiframe indicator	X	X
F3	As F2	Fixed to 0	Fixed to 0
K3	VC trail protection	Fixed to 0	Fixed to 0
N1	Tandem connection OH	Fixed to 0	Fixed to 0

X = Supported

Path Overhead Bytes VC-12

Table 9-21.

VC-12 POH Byte	Function	2 Mbit/s unit
V5 (bit1,2)	BIP-2	X
V5 (bit 3)	REI (transmit only)	X
V5 (bit 4)		Fixed to 0
V5 (bit 5,6,7)	Signal label	X
V5 (bit 8)	RDI (transmit only)	X
J2	Path trace	X
N2	Network operator byte	Fixed to 0
K4		Fixed to 0

X=Supported

Supervision and Alarms

- Plug-in unit indication
  - LED continuously on, diagnostic error
  - LED flashing, transmission signal error
- User panel
  - LED indicators
    - Power
    - Prompt alarm
    - Deferred alarm
    - Info alarm
    - Abnormal
    - Suppressed (alarm cut-off)
    - Station alarm disconnected
    - use CIT
  - Push buttons
    - Suppress (alarm cut-off)
    - Disconnect station alarms
- Miscellaneous discrete input/outputs
    - 8 inputs
    - 4 outputs
- CIT connector F-interfaces V10/RS232
- Access to embedded data communication channels
  - In-station Q-LAN interface, 10-Base-T and 10-Base-2.

Quality and Reliability

10

Overview

This chapter presents Lucent Technologies' quality policy and describes the reliability of the WaveStar® ADM 16/1 Multiplexer and Transport system.

Lucent Technologies' Quality Policy

For Lucent Technologies, quality improvement has long been a vehicle to improve customer satisfaction. For many years, Lucent Technologies' quality programs have been focused on improving products and services. Total Quality programs and benchmarking are important tools in our continuous improvement journey.

As ISO-9000 is a global standard for quality management and assurance, Lucent Technologies wants to use ISO-9000 certification to demonstrate to its customers the company's commitment to producing the best quality products and services. We believe that ISO-9000 registration as an independent assessment of the company's quality system is particularly useful to demonstrate that commitment to quality. In line with this policy, all major transmission facilities in the USA and Europe are ISO-9000 certified.

In line with above, Lucent Technologies' policy statement in this respect is as follows.

POLICY - Quality excellence is the foundation for the management of our business and the keystone of our goal of customer satisfaction. It is, therefore, our policy to:

- Consistently provide products and services that meet the quality expectations of our customers
- Actively pursue ever-improving quality through programs that enable each employee to do his or her job right the first time.

This Lucent Technologies Quality Policy guided the development of the WaveStar® ADM 16/1 Multiplexer and Transport system and will continue to affect the product throughout its lifetime.

Environmental aspects

Lucent Technologies has elected to move forward with ISO 14001 for environmental management systems for its operations and facilities. In fact, as part of our environmental, health, and safety goals, we have committed to have in place EH&S management systems-based on recognized standards such as ISO 14001-for at least 95% of our products, services, operations and facilities by the year 2000.

At the end of year 1998, 23 Lucent facilities, operations, and services have been ISO 14001 certified by third party auditors. The two optical networking group (the business unit that makes the WaveStar® ADM 16/1 Product) manufacturing facilities, has already received ISO 14001 certification, in September 1998.

Lucent's environmental commitment is demonstrated through its structure of environmental and health and safety personnel throughout all levels of the company. A company officer supports the setting of corporate goals and policies, and a Global Environmental Health and Safety vice president oversees environmental aspects for operations worldwide. In addition, each of the business units (including the optical networking group, the unit that manufactures the WaveStar® Product) has its own responsible environment and safety officer. Finally, each facility has environmental managers who are responsible for compliance and the implementation of environmental management systems such as ISO 14001.

Lucent Technologies has developed several effective systems for corporate environmental protection. In fact, Lucent's environmental, health, and safety goals 2000 include having in place EH&S management systems-based on recognized standards-for at least 95% of our products, services, operations, and facilities by the year 2000. The goals for the year 2000 are:

1. Deployment of environmental management systems for at least 95% of our products, services, operations and facilities by the year 2000.
2. Deployment of design for environment criteria for all business groups. As of year-end 1997.
3. Improvement of energy efficiency to avoid the emission of at least 135.000 metric tons of greenhouse gases by the year 2000. As of year-end 1997 110.553 metric tons of carbon dioxide has been avoided.

In addition, in 1997 we deployed the Lucent EH&S worldwide standards, including:

1. Banned substances for products; dyes, pigments and stabilizers; packaging; maintenance and repair of products and production equipment; facilities and operations. A list of banned substances is available on request);
2. Chemical management;
3. Ozone depleting substances;
4. Water and wastewater management;
5. Hazardous waste and contaminated scrap;
6. Transportation of hazardous materials and wastes; and real estate transactions.

Reliability program

Reliability is a key ingredient of the product life cycle, beginning at the earliest planning stage. Major occurrences at the start of the project involved system reliability modeling.

During the design and development stage, reliability predictions, qualification and selection of components, definition of quality assurance audit standards and prototyping of critical system areas ensured built-in reliability.

During manufacturing and field deployment, techniques such as pre-manufacturing, qualification, production quality tracking, burn-in tests, failure mode analysis and feedback and correction further enhance the ongoing reliability of the WaveStar® ADM 16/1 Multiplexer and Transport system.

Reliability specifications

Introduction

The WaveStar® ADM 16/1 provides various hardware redundancy and protective switching mechanisms where necessary to support high service availability.

Redundancy and protective switching

The WaveStar® ADM 16/1 supports the principle that protective switching options should be available for all units and busses that could lead to service degradation when a failure occurs. Therefore, the system is divided into blocks, which allow for separate protection switching. The WaveStar® ADM 16/1 provides protection switching options for the following units:

Unit	Protective switching plan
CC-64/16	1+1, non-revertive
CC-64/32	1+1, non-revertive
PT-stnd	1+1, non-revertive
PT-str3	1+1, non-revertive
PI-DS1/63	1+n, n=8 at maximum, revertive
PI-E1/63	1+n, n=8 at maximum, revertive
PI-DS3/12	1+1, revertive
PI-E3DS3/6+6	1+1, revertive
SPIA-1E4/4B	1:n, n=4 at maximum, revertive
SIA-1/4B	1:n, n=4 at maximum, revertive

Reliability and service availability

The system has a minimal lifetime of 15 years. The reliability of the system can be characterized by the mean time between failures (MTBF is in years). For the WaveStar® ADM 16/1 the MTBF is 2.5 years.

To guarantee service availability a variety of traffic protection mechanisms are supported by the WaveStar® ADM 16/1:

- Path protection or SNC/N (subnetwork connection protection with non-intrusive monitoring) for higher and lower order VCs

- Multiplex Section Shared Protection Ring or MS-SPRing (selective) at STM-16 level.

WaveStar® ADM 16/1 circuit packs fit rates

	Unit Name	Fitrate Unit(in 10^{-9} failures per hour)
Common	FAN	11100 *
	FAN CM1 (paddle board without fans)	330
	PT-Str3/SEC	3950
	T1-DS2 DS0/1	1950
	SC	6900
	SC2	6710
CC	CC-64/16	4100
	CC-64/32	4900
	CC-64/32B	4700
line	SI-L16.1/1, SI-L16 2/1	8350
	SI-L16.1/B SI-L16.2/B	8350
	SI-L16.3/1X	8350
	SI-L16-CR	8300
	SI-16EML80.X/1	8020
	SI-16EML9XXX/1	5940
	LBA-V16.2/1	6070
	LBPA-U16.2/1	10400

trib	SI-S4.1/1	1500
	SI-L4.1/1 SI-L4.2/1	2050
	SI-1/4	6010
	SA-1/4	3600
	SA-1/4B	7200
	SA-0/12	9180
	OI-I.1/2	1090
	OI-S1.1/2	1090
	OI-0/6	3510
	SPIA-1E4/4	1830
	PI-1/4	7800
	PI-DS3/12 PI-E3DS3/6+6	7120
	PI-DS3/6 PI-E3/6	4109
	PI-DS1/63	6550
	PI-E1/63	5860
	IP-LAN/8	tbd
	IP-LAN 8 Tlan+	4517
	IP-GE/2 without optics	3862
paddle boards	PB-1E4/W/2	615
	PB-1E4/PP2/2	780
	PB-E3DS3/6	450
	PB-DS1/100/32	490
	PB-DS1/P100/32	1900
	PB-E1/75/32	24
	PB-E1/120/32	344
	PB-E1/P75/32	495
	PB-E1/P120/32	812

* Note: The manufacturer specifies the L_{10}-lifetime (10% of all fan's have failed) at 45 °C to be 90.000 hours (10.27 years).

Robustness

The WaveStar® ADM 16/1 meets ITU recommendations concerning robustness. This means that:

- Incorrect provisioning of options (software and/or hardware) does not lead to damage or degradation of the units.
- Changing a unit under operational conditions does not lead to damage or degradation of the units.
- When a non-traffic-carrying unit is plugged in or removed, no errors will be caused in the transmission of the system.
- When a traffic-carrying unit is plugged in or removed, no errors will be caused in any traffic not directly related to that unit.
- Short-circuiting of any electrical inputs and outputs (except the Primary Power feeds) on user accessible connectors will not cause any damage or degradation.
- There will be no degradation in the equipment performance when the subrack and each card are individually subjected to a percussion test.
- Insertion of the incorrect card in to any slot will not cause damage to card or slot.
- Removal of any card (including SC) will not inhibit alarms reporting to the station alarm scheme or management system.

Maintainability Specification

The WaveStar® ADM 16/1 requires no periodic maintenance*. Coninuous performance monitoring allows the WaveStar® ADM 16/1 Multiplexer & Transport to detect and report problems before they become service affecting.

* For the subrack equipped with a fan, the filter should be replaced once a year.

Product Support

11

Overview

This chapter describes Lucent Technologies' support for the WaveStar® ADM 16/1 Multiplexer and Transport system. This includes engineering and installation services, technical support, documentation support and training.

Introduction

Lucent Technologies is convinced that product support is an important part of its total product offering. Lucent Technologies offers various services for the planning, implementation and operations of networks with the WaveStar® product family. Services for network planning include economical and technical support and network planning and design. Project implementation services include site-surveys, engineering, installation and testing, acceptance support, database preparation and project management. Operations services such as field support, repair and exchange services, product introduction services and emergency recovery services can be provided. The introduction of the WaveStar® ADM 16/1 system in networks and the corresponding organizations is supported by a comprehensive set of training and documentation offerings.

Engineering and Installation Services

The Lucent Technologies Professional Services organization is committed to providing customers with quality product support services. Whether there is a need for assistance in engineering, installation, normal maintenance, or disaster recovery, the support staff will provide you with the quality technical support you need to get your job done. Each segment of the Professional Services organization regards the customer as its highest priority and understands your obligation to maintain quality service for your own customers.

Within the Professional Services organization, the Engineering and Installation Services Group provides a highly skilled force of support personnel to provide customers with quality engineering and installation services. These engineering and installation specialists use state-of-the-art technology, equipment and procedures to provide customers with highly competent, rapid response services. These services include analyzing your equipment request, preparing a detailed specification for manufacturing and installation, creating and maintaining job records, installing the equipment, and testing and turning over a working system.

Training

The following courses are available for technical staff working with the WaveStar® ADM 16/1 Multiplexer and Transport System:

- SDH introduction course (TR5951)

  This course is designed for technical personnel who need to know the equipment's functional and physical features and the applications and possibilities of the WaveStar® ADM 16/1 system and its management system. The course's high-level approach makes it suitable for personnel from service, purchase and planning departments as well.

  Duration: 2 days

- WaveStar® ADM 16/1 Application and Planning course (TR6000a)

  This course provides an introduction to the features, network applications, unit descriptions, and configurations of the WaveStar® ADM 16/1. The intended audience for this course are technical personnel who need to know the functional and physical features of the equipment and the application possibilities of the system. The course may also be of interest to personnel from sales, logistics, service, purchasing, or planning environments.

  Duration: 1 day

- WaveStar® ADM 16/1 Operation and Maintenance (TR6001)

  This course provides an introduction to the features, network applications, unit descriptions and configurations of the WaveStar® ADM 16/1. The course covers installation, testing, provisioning of equipment, monitoring of events, and maintenance using the ITM-CIT.

  Duration: 5 days

- WaveStar® ITM-SC Operations Course (TR5965)

  This course provides an introduction to the features, network applications, and configurations of the WaveStar® ITM-SC. In addition, this course covers provisioning, monitoring of events, and maintenance activities by means of hands-on exercises using the WaveStar® ITM-SC, for the following network element equipment:

  - SLM-16
  - ISM
  - ADM 155 C
  - Metropolis™ EON a.k.a WaveStar® OLS 80G
  - WaveStar® ADM 4/1
  - WaveStar® ADM 16/1

The course can be modified to cover only those network elements deployed in the customer's network.

Objectives:

To enable students to

- Identify features, applications, descriptions, and configurations.
- Provision site-specific configurations of SDH network elements.
- Interpret system events and apply corrective actions.
- Provide maintenance support.

Duration: 5 days

WaveStar® ADM 16/1 Customer Documentation

General Structure

The SDH customer documentation has a task-oriented approach, based on the task-analysis as performed during the development and implementation of the systems. This leads to different documents each intended to perform a specific task, closely related to the deployment phases of a telecommunications network. These phases are to plan, install, test and maintain the network and its elements.

As a rule, a documentation set covers one particular system (-version) or a compilation of closely related members of a system family. Within the system documentation, the documentation on cooperating sub-systems -if any- is integrated in a modular fashion. However, when systems are part of a certain network application network oriented documentation is made. Because of this, a significant difference is made between network element oriented and network oriented documentation, based on the specific definitions of a network element and a network.

Manual organization

All manuals are provided with:

- front pages, which gives general information about the guide, the overall contents of the guide, how to use it, relations with other documents and conventions and validity statements.
- a number of chapters, clearly separated by numbered tabs. Each chapter has its own table of contents and contains a general introduction explaining what is described and how it is organized into sections. Together with the overall contents of the guide incorporated in the front pages readers can quickly select the information of their interests and/or needs.
- a chapter called “Acronyms and Abbreviations” that are used within the text of the guide.
- a chapter called Glossary, which lists and defines special terms that are used within the text of the guide.
- an Index, which provides easy access to important terms and words used within the text of the guide, by means of page number reference.

However, customer documentation is subject to continuous improvement and therefore the manual organization can change on details, the overall subject coverage remains the same or will increase.

Network Element Specific Documents

The network element specific guides are system oriented documents on network element level, focusing on hardware and ITM-CIT and are shipped to the network element sites only. Types of guides are:

- Cable Layout Manual (CLM)
- Network Element Installation Guide (NIG)
- Network Element Maintenance Guide (NMG)

Cable Layout Manual (CLM)

The Cable Layout Manual describes all mounting and cablings of a specific network element. It forms an important addition to all Physical mounting instructions, that is to mount racks and subracks.

The manual contains functional descriptions of the mechanical part of the subrack as well as technical data, subrack dimensions and instructions how to mount the subrack. Besides, information is given about cable links and arrangement of connectors on the interconnection panel of the subrack.

This manual is intended for installation technicians responsible for mounting the subrack and connecting the interfaces.

Network Element Installation Guide (NIG)

The Network Element Installation Guide contains all information to locally install and start-up an network element, hardware-wise and software-wise to a condition, in which it can be used into an SDH network for the first time.

Installation of hardware comprises the complete procedures necessary to set hardware straps on units, to equip the subracks with units, to provision the system software of all network element types to customer specific configurations and to test the system locally.

Installation of software comprises the complete procedures necessary to install and activate software on the workstation, necessary for further configuration and maintenance of the network element.

After installation, the network element is ready for installation in a network and connection to a management system for further configuration, e.g. provisioning timing, transmission paths, etc.

This guide is intended for installation and testing personnel that takes care of deploying the network elements in the network. However, this manual is also useful for those involved in system projecting and planning tasks or network engineering and administrative tasks.

Network Element Maintenance Guide (NMG)

The Network Element Maintenance Guide contains all information necessary for local maintenance activities of a network element with the use of a Craft Interface Terminal (ITM-CIT), assumed that the network element has functioned properly and no malfunctions are detected so far.

This guide is intended for personnel that takes care of the daily, local maintenance activities on the network element.

Available documents

- Craft Provisioning Guide
- Craft Maintenance Guide
- Alarm Messages and Maintenance Manual.

Release notes

In addition to the Customer Documents as described before, Release Notes are shipped with the product to all sites where equipment is installed. The Release Notes describe general additional guidelines, important things to know, unpredictable behavior and last-minute changes to the parts of the SDH network at delivery time. The Release Notes are intended to guide the user dealing with all operations required during network deployment (installation, testing, maintenance and upgrading) to make optimal use of procedures described in the Customer Documentation. References are made in the Release Notes to the relevant sections, chapters and paragraphs in the Customer Documentation, where applicable.

Related Documentation with focus on Element and Network Management

- **Subnetwork-Controller Installation Guide**

  Information on installation of the WaveStar® ITM-SC.

- **Subnetwork Provisioning Guide**

  Information on configuring or reconfiguring the WaveStar® Network Elements, setting cross-connects and synchronizing your network by using the Navis™ Optical Management Solution-Subnetwork Controller (WaveStar® ITM-SC).

- **Subnetwork Maintenance Guide**

  Information on maintaining the WaveStar™ Network Elements by using the Navis™ Optical Management Solution-Subnetwork Controller (WaveStar® ITM-SC).

- **Subnetwork-Controller Administration Guide**

Information on how to install and start-up software on the WaveStar® ITM-SC Management System, to give users access to the Navis™ Optical Management Solution-Subnetwork Controller (WaveStar® ITM-SC) and to backup and restore databases.

On-line Documentation

On-Line Documentation is created from the information available within the User Documentation.With the software package used on the WaveStar® ITM-SC, called HyperHelp viewer, the files can be viewed and printed, navigated- and searched through. In the near future the on-line documentation can be extended to more context-sensitive information, which is in fact an addition to the help text functionality currently being implemented within the WaveStar® ITM-SC help files.

Glossary

A

ADM
Add/Drop Multiplexer

AIS
Alarm Indication Signal - A code transmitted downstream in a digital network that shows that an upstream failure has been detected and alarmed if the upstream alarm has not been suppressed.

ALS or APSD
Automatic Laser Shutdown

APS
Automatic Protection Switch channel

Asynchronous
Refers to network elements that are not timed from reference traceable to a single Stratum-1 source.

ATM
Asynchronous Transport Mode

B

BER
Bit Error Rate - The ratio of bits received in error to bits sent.

BIP
Bit Interleaved Parity - A method of error monitoring over a specified number of bits (BIP-3 or BIP-8).

BIP-N
Bit Interleaved Parity-N - A method of error monitoring. With even parity, an N-bit code is generated by the transmitting equipment over a specified portion of the signal so that the first bit of the code provides even parity over the first bit of all N-bit sequences in the covered portion of the signal. The second bit provides even parity over the second bits of all the N-bit sequences within the specified portion, etc. Even parity is generated by setting the BIP-N bits so that there are an even number of ones in each of all N-bit sequences including the BIP-N.

Broadband Communication
Voice, data, and/or video communication at rates greater than 2 Mbit/s.

Broadband Service Transport
STM-1 concatenation transport over the SLM-2000 for ATM applications.

C

CC
Cross-connect

CCITT
Comité Consultatif International Télégrafique & Téléphonique (International Telephone and Telegraph Consultative Committee)

CE
Comité Européenne

CEPT
Conférence Européenne des Administrations des Postes et des Télécommunications

CIT
Craft Interface Terminal

CMI
Coded Mark Inversion

Concatenation
Combining the capacity of a multiplicity of Virtual Containers (VCs) into a single container by maintaining the bit-sequence integrity across this container.

CP
Circuit Pack

D

DACS
Digital Access and Cross-connect System

WaveStar™ DACS 4/4/1
One of Lucent Technologies' PDH/SDH-ready digital access and Cross-connect systems.

Default Value Provisioning
The original values are preprogrammed at the factory. These values can be overridden using local or remote provisioning.

DC

Direct Current

DCC
Data Communications Channel - The embedded overhead communication channel in the SDH line. This is used for end-to-end communication and maintenance. It carries alarm, control, and status information between network elements in an SDH network.

DCE
Data Communication Equipment - The equipment that provides the signal conversion and coding between the data terminating equipment and the line. The DCE may be separate equipment or a part of the data terminating equipment.

DCN
Data Communications Network

DCS
Digital Cross-connect System

DDF
Digital Distribution Frame

Defect
A defect is a limited interruption of the ability of an item to perform a required function. It may or may not lead to maintenance action depending on the results of additional analysis.

Demultiplexing
A process applied to a multiplexed signal for recovering signals combined within it and for restoring the distinct individual channels of these signals.

DTE
Data Terminating Equipment - The equipment that originates data for transmission and accepts transmitted data.

Dual Node Interworking
Dual Node Interworking (DNI) is a configuration of two ring networks that share two common nodes. DNI allows a circuit with one termination in one ring and one termination in another ring to survive a loss-of-signal failure of the shared node that is currently carrying service for the circuit.

Downstream
At or towards the destination of the considered transmission stream, i.e. looking in the same transmission direction.

DWDM
Dense Wavelength Division Multiplexing

E

EEPROM
Electrically Erasable Programmable Read-Only Memory

EC
European Community

ECC
Embedded Control Channel

EL
Element Level

EM
Event Management. Subsystem of ITM that processes and logs event reports of the network.

EMC
Electromagnetic Compatibility

EMI
Electromagnetic Interference

EMS
Element Management System

EOW
Engineer Order Wire

EPROM
Erasable Programmable Read-Only Memory

ES
Errored Seconds - A performance monitoring parameter.

ESD
ElectroStatic Discharge

ETSI
European Telecommunication Standardization Institute

Extra Traffic
Unprotected traffic carried over the protection channels when that capacity is not used for the protection of service traffic.

Externally Timed
An operating condition of a clock in which it is locked to an external reference and uses time constants that are altered to quickly bring the local oscillator's frequency into approximate agreement with the synchronization reference frequency.

F

FIT
Failures in Time - circuit-pack failure rate per 10^9 hours is calculated.

Flash EPROM
A new technology that combines the non-volatility of EPROM with the in-circuit reprogrammability of EEPROM (Electrical-Erasable PROM).

Folded Rings
Folded (collapsed) rings are rings without fiber diversity. The terminology derives from the image of folding a ring in a linear segment.

Free running
An operating condition of a network element in which its local oscillator is not locked to any synchronization reference and is not using any storage techniques to sustain its accuracy.

FT-LBA
FT-Lightwave Booster Amplifier

G

Gbit/s
Gigabits per second

GNE
Gateway Network Element - A network element that passes information between other network elements and operation systems via a data communication network.

H

HDLC
High-level Data Link Control; family of layer 2 protocols.

Holdover
An operating condition of a clock in which its local oscillator is not locked to an external reference but is using storage techniques to maintain its accuracy with respect to the last known frequency comparison with a synchronization reference.

I

ICB
InterConnection Box

IEC
International Electrotechnology Commission or Interexchange Carrier

IEEE
Institute of Electrical and Electronic Engineers

I/O
Input/Output

ISM
Intelligent Synchronous Multiplexer

ISO
International Standards Organization

J

Jitter
Jitter is defined as short-term variations of the significant instants of a digital signal from their ideal position in time.

L

LAN
Local Area Network

LBO
Line Build Out - An optical attenuator that guarantees the proper signal level and shape at the receiver input.

Line
An optical transmission line. “Line” refers to a transmission medium, together with the associated high-speed equipment, required to provide the means of transporting information between two consecutive network elements, one of which originates the line signal and the other terminates the line signal.

Loop Timing
A timing mode in which the terminal derives its transmit timing from the received line signal.

LS
Low-Speed part

LVD
Low Voltage Directive (EC)

M

Manager
Is capable of issuing network management operations and receiving events

MCF
Message Communications Function. This function provides facilities for the transport and routing of TMN messages to and from the network manager

Menu
A set of possible values for a parameter.

MIB
The Management Information Base is the database in the node and contains the configuration data of the node. A copy of each MIB is available in the EMS and is called the MIB image. Under normal circumstances, the MIB and MIB image of one node are synchronized.

Midspan Meet
The capability to interface between two Lightwave Terminals of different vendors. This applies to high-speed optical interfaces.

MS
Multiplexer Section

MSOH
Multiplex Section Overhead. Part of the SOH (section overhead). Is accessible only at line terminals and multiplexers.

MSP
Multiplex Section Protection. Provides capability for switching a signal from a working to a protection section.

MTBF
Mean Time Between Failures. The dimension of MTBF is in Years.

Multiplexing
A procedure by which multiple lower order path layer signals are adapted into a higher order path, or multiple higher order path layer signals are adapted into a multiplex section.

N

NE
Network Element. The NE is comprised of telecommunication equipment (or groups/parts of telecommunication equipment) and support equipment that performs network element functions and has one or more standard Q-type interfaces.

nm
Nanometer (10^{-9} meter)

Non-revertive switching
In non-revertive switching, there is an active and standby high-speed line, circuit pack, etc. When a protection switch occurs, the standby line, circuit pack, etc., is selected causing the old standby line, circuit pack, etc., to be used for the new active line, circuit pack, etc. The original active line, circuit pack, etc., becomes the standby line, circuit pack, etc. This status remains in effect when the fault clears. Therefore, this protection scheme is “non-revertive” in that there is no switch back to the original status in effect before the fault occurred.

Node
A node or Network Element is defined as all equipment that is controlled by one system controller.

NPPA
Non-Preemptible Protection Access. Also known as NUT or selective MS SPRing.The user has the option to determine for each VC-4(-4c) individually, whether or not it participates in the MS-SPRing switching scheme. If an individual VC-4(-4c) does not participate then it can be either VC-4(-4c) SNC protected or not protected at all.

NUT
Non-preemptable Unprotected Traffic. Also known as NPPA or selective MS SPRing. The user has the option to determine for each VC-4(-4c) individually, whether or not it participates in the MS-SPRing switching scheme. If an individual VC-4(-4c) does not participate then it can be either VC-4(-4c) SNC protected or not protected at all.

O

OAM&P
Operations, Administration, Maintenance and Provisioning

Operation Interface
Any interface providing you with information on the system behavior or control. These include the equipment LEDs, user panel, WaveStar™ ADM 16/1-EM, office alarms, and all telemetry interfaces.

Operations Interworking
The capability to access, operate, provision, and administer remote systems through WaveStar™ ADM 16/1-EM access from any site in an SDH Network or from a centralized operations system.

OS
Operations System - A central computer-based system used to provide operations, administration and maintenance functions.

OSI
Open System InterConnection

P

Parameter
A characteristic of the system that affects its operation.

Path
A path at a given rate is a logical connection between the point at which a standard format for a signal at the given rate is assembled and the point at which the standard frame format for the signal is disassembled.

Path AIS
Path Alarm Indication Signal - A path-level code that is sent downstream in a digital network as an indication that an upstream failure has been detected and alarmed.

Path Terminating Equipment
Network elements in which the path overhead is terminated.

PBP
Paddle board

PDH
Plesiochronous Digital Hierarchy

Phase Locked
See Externally Timed

Platform
A platform is a family of equipment and software configurations designed to support a particular application.

Plesiochronous Network
A network that contains multiple subnetworks, each internally synchronous and all operating at the same nominal frequency, but whose timing may be slightly different at any particular instant.

PLL
Phase Lock Loop

PM
Performance Monitoring - Measures the quality of service and identifies degrading or marginally operating systems (before an alarm would be generated).

POTS
Plain Old Telephone Service

Pre-provisioning
The capability to provision a slot before installing a circuit pack.

Proactive Maintenance
Refers to the process of detecting degrading conditions not severe enough to initiate protection switching or alarming, but indicative of an impending signal fail or signal degrade defect.

Protection
Label attached to a physical entity. In case of reverse switching, the protection line or circuit pack is the entity that is not carrying service (standby) under normal operation. The label has no particular meaning in case of non-reverse switching.

Provisioning
Assigning a value to a system parameter.

PSTN
Public Switched Telephone Network

PT-stnd
Power and timing circuit pack of WaveStar™ ADM 16/1 providing synchronization and power filtering, 4.6 ppm hold over accuracy.

PT-str3
Power and timing circuit pack of WaveStar™ ADM 16/1providing synchronization and power filtering, 0.37 ppm hold over accuracy.

R

RDI
Remote Defect Indicator - [(Previously called Far-End-Receive-Failure (FERF)] An indication returned to a transmitting terminal that the receiving terminal has detected an incoming section failure.

Receive-direction
The direction towards the cross-connect

Revertive Switching
In revertive switching, there is a working and protection high-speed line, circuit pack, etc. When a protection switch occurs, the protection line, circuit pack, etc., is selected. When the fault clears, service “reverts” back to the original working line.

RSOH
Regenerator Section Overhead. Part of SOH.

S

SC
System Controller

SD

Signal degrade

SDH
Synchronous Digital Hierarchy. Definition of the degree of control of the various clocks in a digital network over other clocks.

Section
A transport entity in the transmission media layer network which provides integrity of information transfer across a section layer network connection by means of a termination function at the section layer.

SEFS
Severely Errored Frame Seconds - A performance monitoring parameter.

Self-healing
A network's ability to automatically recover from the failure of one or more of its components

SEMF
Synchronous Equipment Management Function. This function converts performance data and implementation-specific hardware alarms into object-oriented messages for transmission over the DCC and/or Q-interface. It also converts object-oriented messages related to other management functions for passing across the S reference points

Service
The operational mode of a physical entity that indicates that the entity is providing service. This designation changes with each switch action.

SES
Severely Errored Seconds - A performance monitoring parameter.

SF
Signal Fail

SLM
Synchronous Line Multiplexer

SOH
Section Overhead. Capacity added to either an AU-4 or assembly of AU-3s to create an STM-1. Contains always STM-1 framing and optionally maintenance and operational functions. SOH can be subdivided in MSOH (multiplex section overhead) and RSOH (regenerator section overhead).

SONET
Synchronous Optical NETwork

Standby
The operational mode of a physical entity that indicates that the entity is not providing service, but standby. This designation changes with each switch action.

STM
Synchronous Transport Module Building block of SDH.

Subnetwork
A group of interconnected/interrelated network elements. The most common connotation is an SDH Network in which the network elements have data communications channels (DCC) connectivity.

Synchronous
Refers to Network elements that are timed from references traceable to a single Stratum-1 clock source.

Synchronous Network
The synchronization of synchronous transmission systems with synchronous payloads to a master network clock that can be traced to a single reference clock.

T

TMN
Telecommunications Management Network

Transmit-direction
The direction outward from the cross-connect.

Tributary
A 2 Mbit/s, 34 Mbit/s, 45 Mbit/s, 51.84 Mbit/s (STM-0), 140 Mbit/s (CEPT-4), 155 Mbit/s (STM-1) or 622 Mbit/s (STM-4) signal within the WaveStar™ ADM 16/1 System.

TSA
Time Slot Assignment

TSI
Timeslot Interchange

U

UAS
Unavailable Seconds - A performance monitoring parameter.

Upgrade
An upgrade is the addition of new capabilities (feature). This requires new software and may require new hardware.

Upstream
At or towards the source of the considered transmission stream, i.e. looking in the opposite direction of transmission.

V

Value
A number, text string, or other menu selection associated with a parameter.

W

WDM
Wavelength Division Multiplex

Wideband Communications

Voice, data, and/or video communication at digital rates from 64 kbit/s to 2 Mbit/s.

Working
Label attached to a physical entity. In case of revertive switching, the working line or circuit pack is the entity that is carrying service under normal operation. In case of non-revertive switching, the label has no particular meaning.

WS
Workstation