

10-Gbit/s DWDM System with a Band Management Feature

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OVERVIEW: As the use of dark fiber as a backbone of carriers is becoming common, an increasing number of carriers are adopting dense wavelength division multiplexing (DWDM) systems in their networks, which results in growing market demand for systems with large capacity and high flexibility in transmission performance. Hitachi has added to its lineup of the AMN series a 10-Gbit/s metro core DWDM system, AMN6050. AMN6050 directly accommodates 10-GbE and GbE signals, thereby making it possible to use DWDM systems efficiently. Also, with a newly developed band management module (BMM), the system can manage the wavelength band, select wavelengths for specified routes, and transmit multiplexed signals with different transmission characteristics into the same fiber. Based on broad experiences in delivering ultra-long-haul and long-haul 10-Gbit/s-class DWDM systems, Hitachi can design flexible optical networks. As a support service in building optical backbone networks, Hitachi participates in the design of networks from the preparation stage. Also through site/route surveys, Hitachi provides various services to build better-suited networks and enable stable transmission. Thus, Hitachi is more than simply a provider and installer of network equipment — it is a provider of total optical transmission solutions.

INTRODUCTION

ALONG with the spread of IP (Internet protocol) networks in the public infrastructure, there has been a growing need to build a high-speed optical backbone. Furthermore, with the number of variations in networks including overbuild high-speed networks and those that take advantage of existing networks constantly increasing, there is an urgent need in the market not only for proposals covering new network equipment but also for better support services in network design. Hitachi believes that it is important to offer such support services to keep close relationship with its customers in order to proceed smoothly with building next-generation DWDM mesh-type networks, which used to be difficult to do merely by designing a series of DWDM networks on a point-to-point basis. Fig. 1 shows the typical configuration of a mesh-type network using Hitachi's DWDM system with its band management feature. This paper describes Hitachi's 10-Gbit/s optical transmission solutions, applications based on the metro core DWDM system AMN6050, and support services we offer in building optical backbone networks.

DWDM TECHNOLOGIES FOR METRO NETWORKS USING 10-Gbit/s METRO CORE DWDM SYSTEM "AMN6050"

In addition to its backbone-type AMN6100 DWDM system, Hitachi has released a 10-Gbit/s AMN6050 metro core DWDM system, which makes high-flexibility networks a reality¹⁾. Hitachi's knowhow about 10-Gbit/s transmission obtained through the development of its long-haul systems has thus been adapted for metro areas.

For DWDM systems to be used for metro applications, they need to:

- (1) Directly accommodate OC-192/STM-64 and 10-GbE interfaces at a transmission speed of 10 Gbit/s per channel.
- (2) Enable smooth system installation and wavelength addition to the 10-Gbit/s base.
- (3) Support the expansion of 10-Gbit/s signals into four channels by using the basic package.
- (4) Have a transmission capacity of 320 Gbit/s per bay.
- (5) Enable installation in 19-inch (483 mm)/23-inch (584 mm) bays.

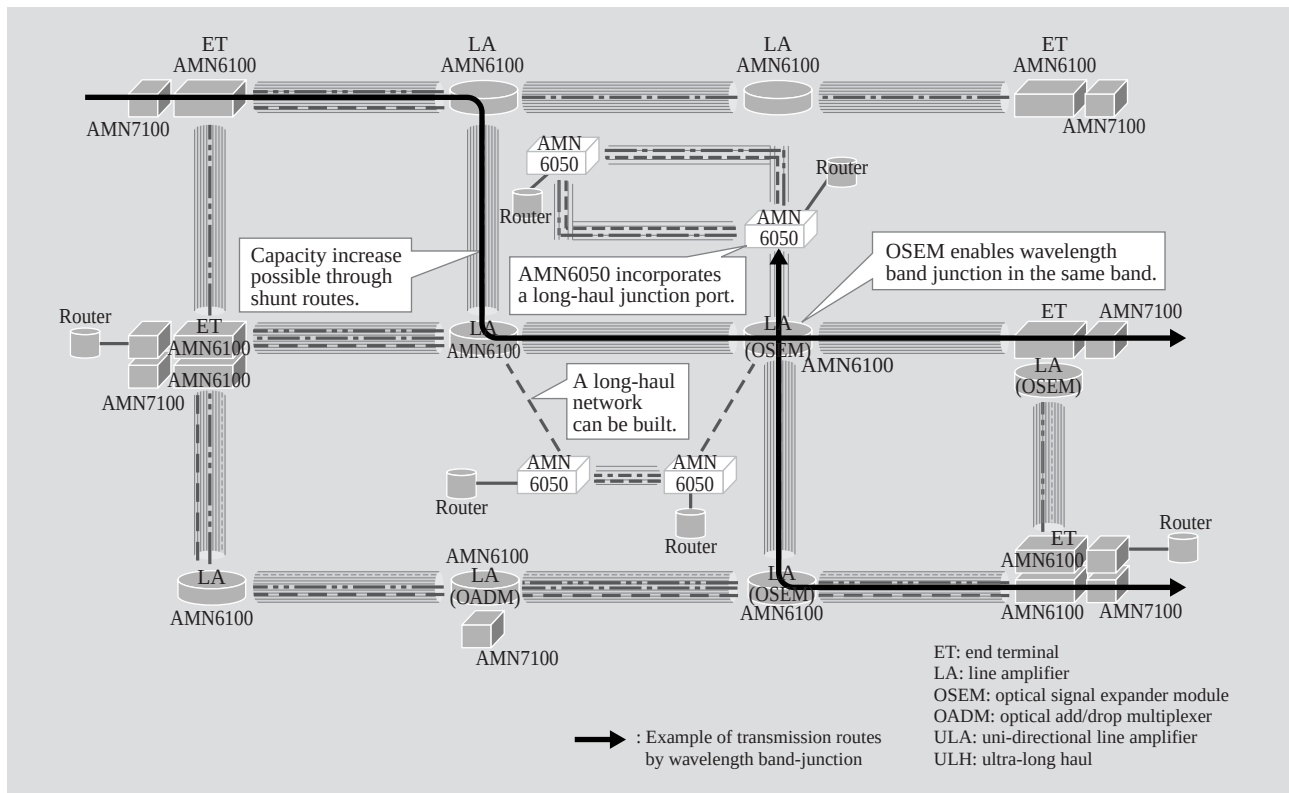


Fig. 1—Typical Configuration of a Band-Junction Mesh-Type Network Using Hitachi's DWDM System with Band Management Feature.

Hitachi's band management feature makes flexible networks a reality and reduces the cost of building the system by using wavelength multiplexing.

(6) Enable installing the same system on another bay, and provide back-to-back installation.

(7) Provide front access and ventilation.

Described below is an adaptation of the AMN6050 system to meet the market needs above.

As a minimum function for DWDM, interfaces should be installed in universal slots where needed. Taking into account the major interfaces now in use and this requirement, we plan to accommodate OC-192/STM-64, OC-48/STM-16, 10-GbE, GbE, fiber channel, and other interfaces in the AMN6050 system.

AMN6050 is based on the long-haul technology of a backbone DWDM system, AMN6100. The automatic gain control (AGC) function incorporated in AMN6050 for wavelength multiplexing allows to regulate the gain of each wavelength individually, so that the system can be installed smoothly, and wavelengths can be added as plug-and-play.

The band management module (BMM), one of the packages, is a module where it's maximum of 32, 10-Gbit/s signals are multiplexed in four-channel unit. It divides the C band of the ITU-T grid into a red and a

blue band, with each band being expandable.

To enable system installation in datacenters and similar facilities, the system can be accommodated not only in a general-purpose 23-inch bay, but also in a 19-inch bay (EIA), with a maximum transmission capacity of 320 Gbit/s. If the system cannot be installed in the same rack as "add-on" due to space limitations, it can be installed in another bay or back-to-back. The system thus allows flexible bay configuration.

A DWDM NETWORK CONFIGURATION BASED ON AMN6050 AND AMN6100

Integration of Long-haul and Metro Networks with Different Transmission Characteristics

Products in conventional DWDM systems differ according to transmission distance, that is, according to their use in a long-haul or metro network. It is therefore difficult to integrate and manage a long-haul network and a metro network and to combine network plans. Products are separated because it is difficult to multiplex signals and transmit them on the same fiber between networks with different transmission

characteristics. For example, even if we had a long-haul and a metro network, meshing the networks would still be difficult, due to problems with interfacing and the complexity of equipment configuration for combining the networks.

Hitachi has introduced its AMN6050 and AMN6100 systems to enable DWDM transmission in long-haul and metro networks having different transmission characteristics. The systems enable highly efficient band-junction transmission based on wavelength multiplexing with optical amplification. For example, as Fig. 2 shows, the red band is allocated for the metro-ring network, and the blue band is allocated for the long-haul network. An optical interface mounted on the AMN6050 and AMN6100 systems as standard equipment is used to combine signals to transmit them via the same optical fiber as multiplexed signals.

Features of AMN6050 for Flexible Networking

The following features of the AMN6050 system enable flexible networking:

- (1) It eliminates limitations on transmission distance that varies with different wavelengths.
- (2) It provides static wavelength conversion as well as conversion to the wavelength band where the density can be easily increased without lowering the

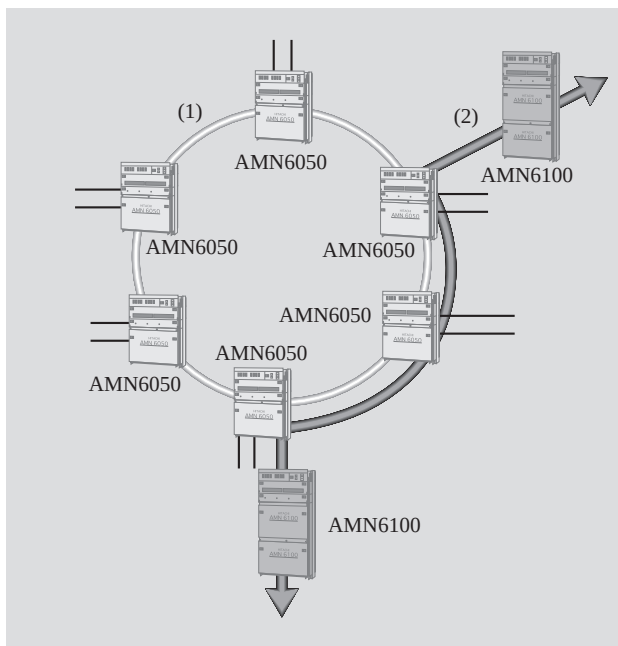


Fig. 2—Combining of Metro-ring and Long-haul Networks. By combining AMN6050 and AMN6100, we can integrate the management of metro-ring (1) and long-haul (2) networks with different transmission characteristics.

number of multiplexed signals.

(3) It supports various network configurations for different transmission environments and needs, for different types of fiber, and increases the transmission distance significantly in long-haul, ring, star, and mesh networks.

(4) It enables adding nodes without affecting services in operation because the system is expandable on a band-by-band basis (see Fig. 3).

Key Technologies of AMN6050

(1) A band-managed low noise figure (LNF) optical amplifier

It achieves LNF for the entire system, provides a band junction, and maintains wavelength multiplexing efficiency, thus ensuring stable transmission performance. Also, it lowers the power inserted into optical fiber and improves the non-linearity of transmission fiber. It ensures an optical S/N ratio margin for the system, and helps to increase the DWDM transmission performance, such as span margin and leeway in the number of wavelength multiplexings. In addition, the amplifier does not use a variable attenuator to reduce transmission loss.

(2) A band management module

With four wavelengths used as one unit, the system compensates for transmission limitations and static wavelength conversion and multiplexes the wavelengths having different routes in the same fiber. (3) Optical amplifiers with in-band/total-learning optical output control

The system prevents changes in the optical output level per wavelength due to changes in the number of

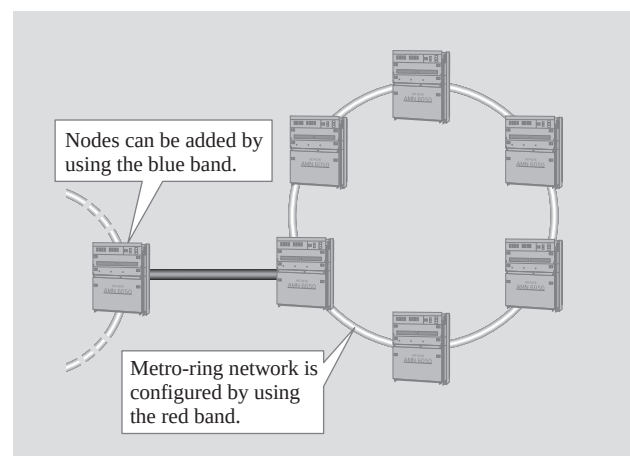


Fig. 3—Adding Nodes after Building Metro-ring Network. Band junction makes it possible to add nodes by using blue band after building a metro-ring network by using the red band.

multiplexed wavelengths, such as when the band is divided or combined. It keeps the output at a level appropriate for each amplifier. In-band/total learning control enables a robust response to the addition and reduction of wavelengths, and it is incorporated in the optical amplifiers. Very small differences in the gain tilt of the amplifiers, and very small changes in the gain tilt due to span changes are corrected in each amplifier through total learning control. These very small differences are thus automatically corrected at each amplifier, and the optical output is controlled with high precision.

SUPPORT SERVICE FOR BUILDING OPTICAL BACKBONE NETWORKS

In building DWDM networks, it is important to monitor the status of the optical fiber, as well as the number of wavelengths, the transmission capacity, the transmission distance, and so on. Thus, it is important to provide customers building such networks with continuous support, from proposing network configuration to conducting a site survey before installation and providing support up to operation, without functioning as a mere installer of the equipment (see Fig. 4).

Before introducing systems, Hitachi can conduct site surveys to provide customers with quantitative data that can help them understand any fiber-related problems that will directly affect the system performance. Based upon the results of a site survey, Hitachi makes proposals to build networks in a short time and with high efficiency.

What Is a Site Survey?

Hitachi can accurately determine site conditions for stable DWDM transmission as part of its efforts to improve network design quality for DWDM systems. To achieve this, Hitachi refreshes the fiber and measures various optical characteristics before delivering the system. Moreover, in an attempt to help customers use their systems in a better environment depending on the field status, the company offers to conduct a site survey. Hitachi can measure reflection in the fiber, losses in transmission lines, and so on.

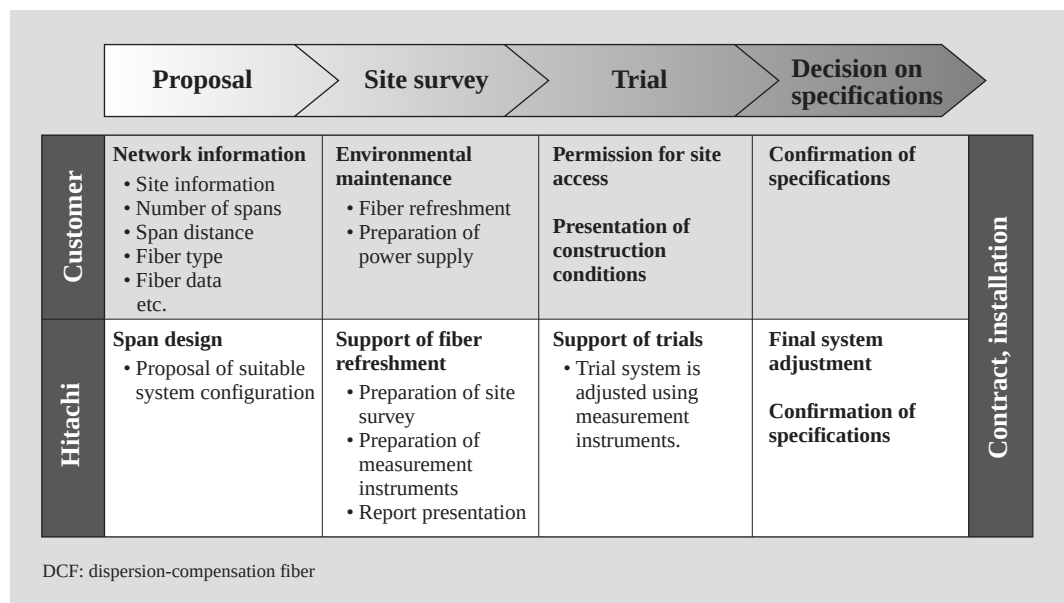
Such measurements make it possible to conduct a comprehensive analysis, refresh dark fiber lines, eliminate lines likely to cause problems, and manage data obtained via different types of fiber in transmission lines, thus producing effective network design.

Necessity for Site Surveys

Technologies for reducing losses in optical connectors and splices are remarkable. In general, however, there are many human factors that can produce variations in loss, dirtiness, reflections of connector, and other characteristics in actual lines. Furthermore, it is inevitable that different kinds of optical fiber or fibers from different lots get mixed due to project conditions resulting from reasons related to the route and site construction.

Hitachi intends to offer its customers route and site surveys to provide them with a quantitative understanding of real line status and to help them cope efficiently with complicated problems in DWDM

Fig. 4—Tasks in Introducing a DWDM System. Continuous support from proposing network configuration, to conducting a site survey before installation, to installation.



systems that perform effectively only when the customer's fiber fits the system. Hitachi believes that conducting a site survey before introducing a system will stabilize DWDM transmission and improve the accuracy of estimation of the maximum number of wavelengths in transmission lines, which will help customers with network expansion.

CONCLUSIONS

This report described Hitachi's support for the building optical backbone systems including 10-Gbit/s metro core DWDM system AMN6050 for optical backbone networks.

To make optical backbone systems a reality, it is important not only to increase the basic performance of DWDM system, but also to accurately determine the state of existing optical fiber and to provide total solutions designed to build systems efficiently. Hitachi continues to propose effective network solutions.

REFERENCE

- (1) "'AMN6100' 1.28-Tbit/s Ultra-long Haul Wavelength Division Multiplexing Transmission System," *Hitachi Technology* 2001-2002, 7 (Aug 2001). <http://global.hitachi.com/Sp/TJ-e/2001/technology/TECHNOLOGY1.pdf>

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