YOKOGAWA'S CONTRIBUTION TO THE OPTICAL COMMUNICATION FIELD

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This paper outlines Yokogawa's activities in the field of optical communications, which are one of the most important social infrastructures in the 21st century. It examines how Yokogawa provides total solutions ranging from modules to subsystems and measuring instruments, and reviews the future direction of optical communication technologies and Yokogawa's prospects.

INTRODUCTION

Network traffic is increasing rapidly. The traffic in the networks of Japan Internet Exchange Co., Ltd. (JPIX), which is often cited as an example of a steep rise, increased from 70 Gbps to 100 Gbps (peak value) last year, a rise of 43%*. Although optical communication technologies have increased speeds and wavelength division multiplexing (WDM) technology has been developed to handle the larger capacities, the speed and capacity need to be increased further to cope with the recent surge in communication traffic. This is because subscribers of FTTH (Fiber To The Home) grew from 10 thousand in 2001 to 11 million at the end of 2007 and this growth in users has enabled various commercial services to be provided via optical communication networks, which were still at the planning during the telecommunications bubble. Thus, to provide these services, communication infrastructure must be established based on actual needs. Moreover, there has been discussion on integrating communication and broadcasting in Japan because analog broadcasting will be terminated in 2011; this would require the communication infrastructure to be enhanced even further. In response, 40-Gbps transmission technologies were introduced into commercial networks in 2007 and 100-Gbps transmission technologies are now being discussed in academic conferences on optical communication.

The main optical communication methods used to transmit digital signals by light pulses. However, wave distortion through optical fibers is not negligible at speeds exceeding 10 Gbps, which reduces the transmission distance. To overcome the problem, methods of transmitting digital signals by using the difference of optical phases were developed and are being introduced into commercial networks, namely Differential Phase Shift Keying (DPSK) and Differential Quadrature Phase Shift Keying (DQPSK).

Yokogawa recognizes that optical communication will be an important infrastructure in the 21st century, and produced the world's first transponder using 40-Gbps RZ (Return to Zero)-DQPSK technologies in 2007. We also developed optical measuring instruments such as OTDR or optical spectrum analyzers, as well as wavelength monitors for WDM, transport analyzers, and optical phase modulation analyzers. Thus, we are a manufacturer which can offer total solutions from measuring instruments to communication subsystems. At Interop Tokyo 2008 held in June, our efforts were rewarded: the latest small-size 40-Gbps RZ-DQPSK transponder "global model" won the Special Judges' Award Grand Prix and the optical phase-modulation analyzer won the Special Award in the measurement category. We have been developing ultra high-speed optical switches, burst mode clock recovery (Burst-CR) IC, and optical packet networks for the future.

This paper describes Yokogawa's development history, the future direction, and our prospects.

DEVELOPMENT OF COMPOUND SEMICONDUCTOR TECHNOLOGY AND ENTRY INTO THE OPTICAL COMMUNICATION MARKET

In 1983, Yokogawa started developing compound semiconductor devices to produce key devices for high-frequency measuring instruments. After ten years of research and development, the company successfully incorporated its own devices into digital oscilloscopes, LSI test systems, and near-infrared spectrometers.

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In optical communication fields, photo diode arrays (PDA) are installed in wavelength monitors for WDM. The key to our success was that we developed PDAs which guaranteed all photodiodes perfectly work; others PDAs had not been commercially available. Through developing wavelength monitors, we also accumulated micro-optics technologies.

In 2001, Yokogawa announced its entry into the optical communication business with 40-Gbps optical communication modules, which are based on compound semiconductor technologies as one of our core competencies. The 10-Gbps technology was first introduced in 2000 and seemed to become widespread in 2001, so we judged it too late to enter the 10-Gbps market. Yokogawa therefore targeted the 40-Gbps market, which is the next-next generation that would take off in 2003 or 2004.

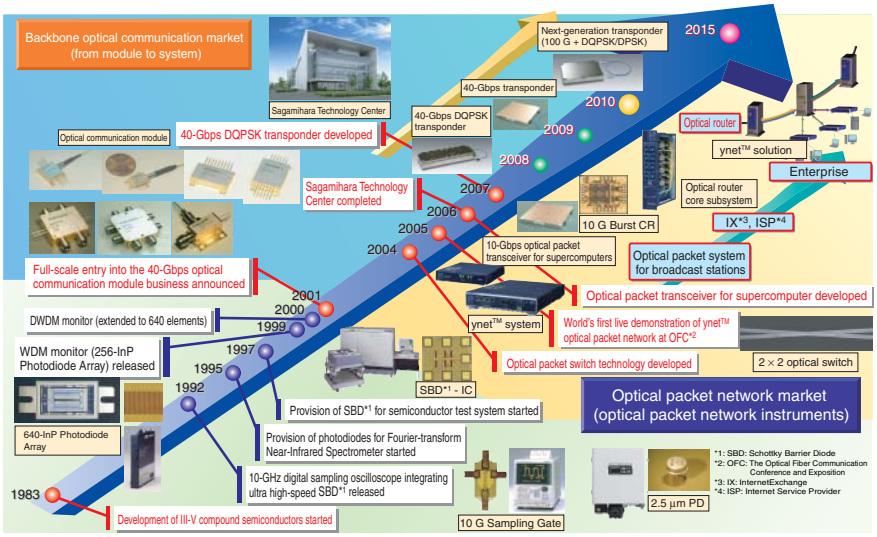

Figure 1 Roadmap for Technologies Centering on Compound Semiconductor

However, the communications bubble burst in the spring of 2001 due to the "last mile/first mile" problem, which means lack of end-users. After four years of a stagnant market, the 10-Gbps market and 40-Gbps test sample market took off in 2005. 40-Gbps technologies are now being introduced widely in 2008, and the stagnation of the market actually benefited us. During that time, Yokogawa consulted leading users, received sample evaluations and feedback from them, used the results to develop elemental technologies, and thus created mature 40-Gbps technologies.

As a result, we built a business foundation by manufacturing photo diodes, modulator drivers, and clock management modules, and announced the 40-Gbps RZ-DQPSK transponder in 2007.

YOKOGAWA'S APPROACH TO OPTICAL SWITCHES AND OPTICAL PACKET NETWORKS

Although communication is carried out via point-to-point connection in conventional optical communication technologies, dynamic multipoint-to-multipoint connection will be required in the future. The ultimate mode of multipoint-to-multipoint connection is an optical packet network, since the optical signals in the network are not converted to electrical signals but are transmitted as packets to the destination via switching nodes. The important elemental technologies for the system are ultra high-speed optical switches and the Burst-CR technology.

Yokogawa had already developed in 2003 an optical switch that operates in less than 2 nanoseconds. This switch is applicable not only to optical packet networks but also to packet exchanges at the backplanes such as the connections among calculation nodes of supercomputer systems and optical routers.

In 2005, Yokogawa announced the ynet™, the world's first 40-Gbps optical packet network system, and has since been improving each elemental technology.

As for the Burst-CR technology, Yokogawa has been working to shorten the lock-in time and developed an IC which can lock in within 50 ps equivalent to a half bit at 10 Gbps. We also developed a 10-Gbps optical packet transceiver incorporating the optical packet transmission technology.

We are now improving the 40-Gbps Burst-CR IC in the ynet™ which has some operational restrictions to a model that can be applied to any network design.

YOKOGAWA'S PROSPECTS

Optical communication technologies are expected to develop in two ways: higher speeds and greater flexibility. As for higher speeds, the 40-Gbps technology is already in use, and the technology for more than 100 Gbps (100 G+) will become the mainstream in the development race. Yokogawa has started developing elemental technologies for 100 G+ in order to be one of the companies supporting the communication infrastructure beyond 40 Gbps. As for flexibility, the revolution from point-to-point connection to dynamic switching has just started: the Re-configurable Optical Add-Drop Multiplexer (ROADM), a device which switches light routes within milliseconds, is now being used. We are determined to help build more dynamic networks through our proprietary technologies such as ultra high-speed light switches and optical packet technologies.

Last year, major government-supported projects such as the New Generation Network Promotion Forum and the Green IT Promotion Council started. We will work closely with such projects and contribute to society by supporting the social infrastructure. ◆

* (http://www.jpix.ad.jp/jp/techncal/traffic.html)