AQ2200-136 COMPACT TUNABLE LASER SOURCE MODULE FOR WIDE WAVELENGTH RANGE

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We have developed the AQ2200-136 compact tunable laser source module with a wide wavelength range of 200 nm (1440 to 1640 nm) and a maximum output power of +7 dBm or greater, as a plug-in module for the AQ2200 multi-application test system (MATS). When combined with the AQ2200 series of optical sensors or the AQ6317B/C/AQ6319 optical spectrum analyzer, the AQ2200-136 enables users to measure the wavelength-dependent loss (WDL) of an optical device without any personal computers. In this paper, we describe the features and structure of the AQ2200-136.

INTRODUCTION

Among optical fiber communication-related markets, the increase in Ethernet speeds and the spread of the broadband connection have induced the expansion of the Fiber to the Home (FTTH) market. These two factors have also sparked the growth of the metro Wavelength Division Multiplex (WDM) market. This market has been stagnant for a long time, but has been showing signs of recovery in recent years. However, demands for cost reduction have been growing for parts and systems employed in the metro WDM—ranging from transmission systems to optical parts. Therefore, an increase in production volume does not necessarily lead to an increase in sales. Inevitably, measuring instruments employed in the metro WDM are required to offer benefits relating to measurement cost reduction (lower price, productivity enhancement, space saving, etc.).

In the FTTH market, wavelength ranges for image signals have been added, and the allocation of wavelength ranges changed. The wavelength range of the metro WDM is expanding. Accordingly, laser sources increasingly require a wider wavelength range and higher output power.

We have developed the AQ2200-136 Compact Tunable Laser Source (TLS) Module. This module is one of the plug-in modules for the Multi-Application Test System (MATS) of the AQ2200 series that we developed in response to demands for greater accuracy in measurement for optical transmission devices and parts.

Figure 1 shows an external view of the AQ2200-136TLS Compact TLS Module.

FEATURES

The features of the AQ2200-136 Compact TLS Module are as follows:

- Wide wavelength range

  The wavelength is continuously tunable in the 200-nm wavelength range of 1440-1640 nm.

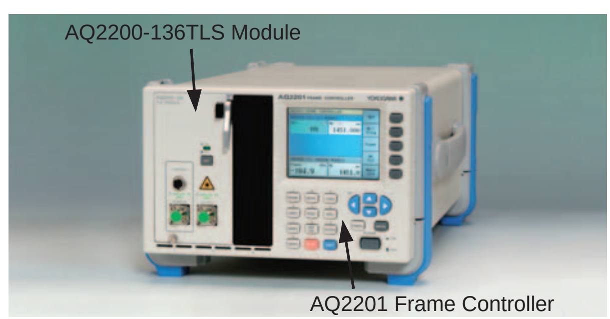

Figure 1 External View of the AQ2200-136TLS Compact Tunable Laser Source Module

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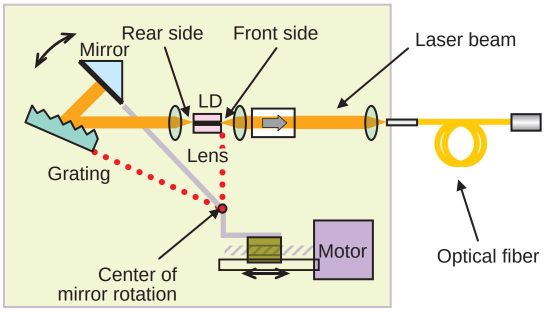

Figure 2 Structure of the Variable Wavelength Module Block

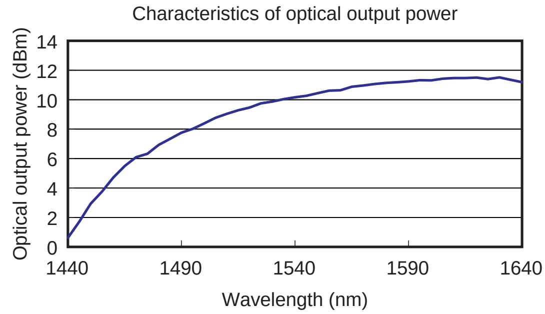

Figure 4 Characteristics of Optical Output Power with Respect to Wavelength

- Compact and strong body
  The compactness and great strength of the body are achieved by mirror arm support and a shock absorbing structure using a damper.

STRUCTURE OF TLS MODULE

Principles

Figure 2 presents the structure of the tunable wavelength module block. High reflective (HR) coating is applied on the front side of the laser diode (LD), and anti-reflective (AR) coating on the rear side. The LD and the mirror mounted outside the module constitute a laser cavity. One wavelength is selected at the grating from wavelengths of different modes generated from the cavity. A single-mode laser beam is emitted from the front side of the LD. By rotating the mirror, the laser cavity length is changed to make the wavelengths tunable. In Figure 2, the tunable wavelength module block is in a Littman configuration, where the same oscillation mode is selected for tunable wavelengths. Continuous sweeping of wavelengths is possible while minimizing the possibility of a mode hop occurrence.

Main Components

Figure 3 shows a functional block diagram of the AQ2200-136 Compact TLS Module.

Tunable Wavelength Module

To obtain a tunable wavelength range of 200 nm by one LD, the LD must be combined with other components of the laser cavity, namely, the lens and grating, in the optimum manner. We conducted research on the laser cavity in regard to optimizing it and reached the conclusion that a new LD needs to be developed. Therefore, we requested NTT Electronics to develop a new LD on our behalf, since NTT Photonics Laboratories, which is known for research in the field of communication semiconductor lasers, transfers its technologies to NTT Electronics.

The wavelength range of single-mode oscillation by one LD is insufficient, so the laser cavity length needs to be adjusted to acquire a wavelength range that satisfies the product specifications, for which a high positioning accuracy of 0.5 μm is needed. A highly accurate new YAG welding technology that allows for adjustment down to at least 0.1 μm and a new measurement technology with a minimal positional error have been developed.

The employment of these technologies has enabled a tunable wavelength range of 1440-1640 nm, which is twice as wide as the range achieved by our conventional technologies. Figure 4 depicts the characteristics of optical output power with respect to wavelength. Figure 5 presents a graph representing wavelength reproducibility.

This product employs a hollow structure in which the LD block is placed in between circular supports of the mirror arm (Figure 6). It was not easy to prevent the optical and drive systems from interfering with each other in the past, but we have developed a mechanism to prevent such interference from occurring.

These improved technologies have allowed for the construction of a Littman configuration in a small device. A TLS

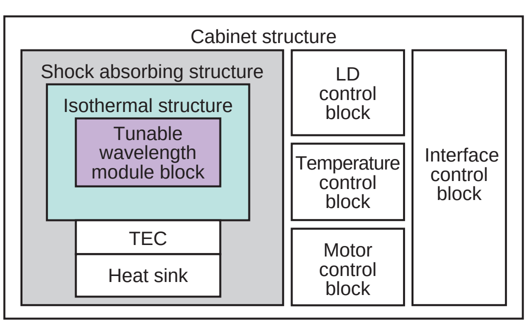

Figure 3 Functional Block Diagram

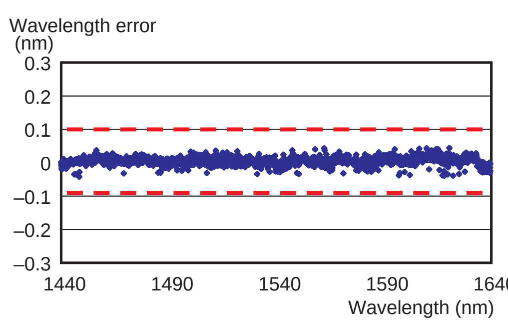

Figure 5 Wavelength Reproducibility

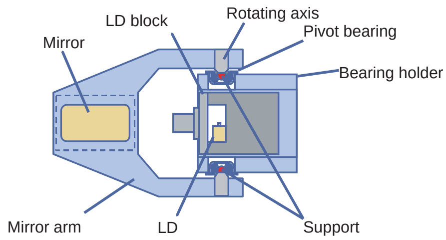

Figure 6 Mirror Arm Support Structure

module capable of continuous wavelength sweeping and mountable in a 2-slot-wide module of the AQ2201 Frame Controller has been developed.

Cabinet Structure

This product is of the plug-in module type that is mountable on the AQ2201/AQ2202 Frame Controller.

It can be combined with another measurement module, and both of them can be mounted together on the frame. Therefore, measurement modules must be mounted, such that the heat of one measurement module does not adversely affect the performance of the other. The compact nature of this product allows for easy mounting and removal, whose impact on internal components must be thoroughly addressed.

The positioning accuracy required for laser cavities is 0.5 µm, which is very high. A positional error can easily occur due to thermal expansion and shrinkage caused by ambient temperature changes. Thus, materials with different coefficients of thermal expansion were combined to build a structure to prevent the adjustment position from being displaced.

The tunable wavelength module block is encased in an isothermal structure to minimize the effects of ambient temperature changes. Also, a Thermo Electric Cooler (TEC) device is employed to control the temperature of the entire isothermal structure. Changes in the ambient temperature of the laser cavity are minimized accordingly, thereby enabling stable operation at tunable wavelengths. However, this temperature control method employs a high-capacity TEC device which generates a large amount of heat that needs to be efficiently released outside. This product is also of the plug-in module type from which the transferring of heat to neighboring modules must be avoided. Therefore, the heat cannot be transferred to the cabinet for release. To solve this problem, we have developed a highly efficient dedicated heat sink which releases the generated heat to the air inside the cabinet, instead of directly transferring it to the cabinet. According to the heat simulation results (Figure 7), the flow of wind inside the TLS module was optimized. As a result, the maximum difference between the temperature of the side surface of the TLS module and that of its ambient air is 6ºC.

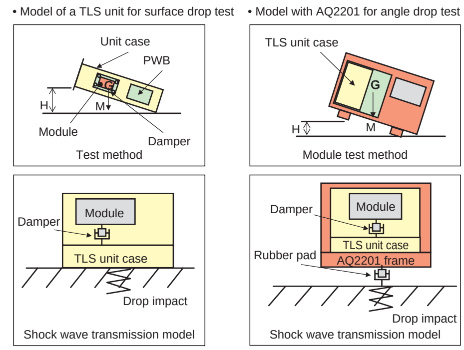

Figure 8 Drop Test Method and Shock Wave Transmission Model

Shock Absorbing Structure

The tunable wavelength module block of this product is provided with very accurate adjustment, so excessive shock should not be exerted on the product. When a positional error or damage occurs, adjustment or repair is difficult. To optimize the structural design, we constructed shock wave transmission models for the TLS module and for the same module mounted on the AQ2201/AQ2202 Frame Controller. These models were used to analyze shock waves transmitted to the TLS module when it is removed from and mounted on the Controller. The standard value of the maximum shock on the tunable wavelength module block was 50 G.

Figure 8 shows the drop test methods and the shock wave transmission models. In compliance with JIS C0043 Surface Drop Test, we set the test height (H) to 50 mm. The tunable wavelength module block of this product is supported by an shock absorbing structure using a damper. The maximum shock on the tunable wavelength module block of 50 G has been achieved.

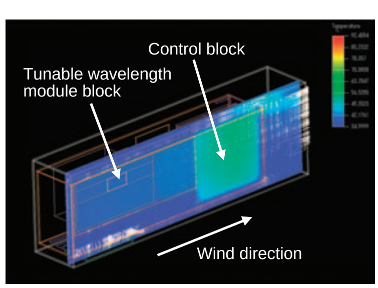

Figure 7 Thermal Simulation Results

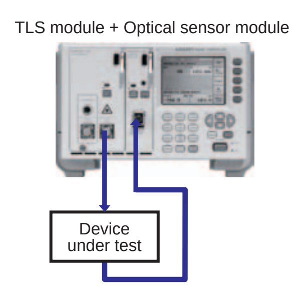

Figure 9 Synchronized Wavelength Sweeping Measurement by the Optical Sensor Module and the TLS Module Combined

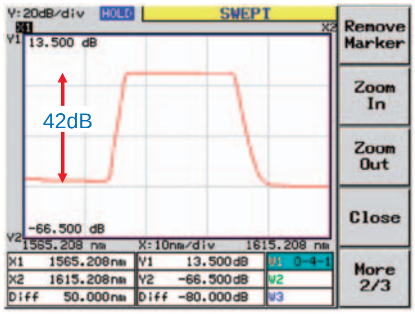

Figure 10 Screen of WDL Measurements by the Optical Sensor Module and the TLS Module Combined

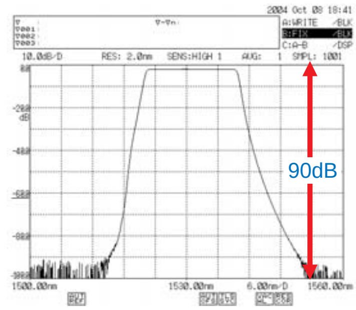

Figure 12 Example Measurements by the TLS Module and the Optical Spectrum Analyzer Combined

EXAMPLE MEASUREMENTS OF WAVELENGTH DEPENDENCE OF OPTICAL DEVICE

Combination with Optical Sensor Module

Figure 9 shows a high-speed and space-saving Wavelength-Dependent Loss (WDL) measurement system. This system can be constructed by mounting the AQ2200-136TLS module and the optical sensor module of the AQ2000 series on the AQ2201 Frame Controller.

In the WDL measurement system, the wavelengths of the TLS module is tuned and continuously changed (swept) in one direction in an arbitrary wavelength range. Also, the set wavelength is synchronized with the optical sensor module in order to measure WDL. To synchronize signals from the TLS and the optical sensor, different commands used to be sent to these two destinations via GP-IB or the like. As measurement points were added to increase the wavelength resolution, the waiting time increased for synchronizing the set wavelength of the TLS with the optical sensor. In addition, the data transfer time increased for incorporating measured data from the optical sensor. The measurement throughput was compromised accordingly. In this product, one frame is mounted with the TLS module and the optical sensor module alike. As a result, casual factors of the throughput loss are minimized to enable high-speed WDL measurement.

It used to take approximately 70 seconds for synchronous WDL measurement via GP-IB when the measurement resolution is 0.01 nm in a wavelength range of 1440-1640 nm. The same measurement using this product takes only 21 seconds. Also, this product presents WDL measurements on the screen in real time (Figure 10).

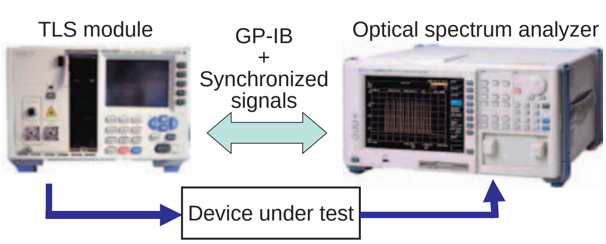

Figure 11 Synchronized Wavelength Sweeping Measurements by the Optical Spectrum Analyzer (AQ6317B/C/AQ6319) and the TLS Module Combined

Combination with Optical Spectrum Analyzer

For WDL measurement, the TLS module can also be combined with the optical spectrum analyzer. In measurements using a combination of the TLS module and the optical sensor module, Source Spontaneous Emission (SSE) of the TLS module are measured by the sensor. When measuring the critical value of the amount of optical cutoff using an optical cutoff filter or the like, the critical value may not be measured in cases where signal components of the optical cutoff are covered with SSE.

However, the combination of the TLS module and the optical spectrum analyzer enables measurement in a higher dynamic range because the optical spectrum analyzer has a filter function with a grating to suppress the SSE (Figure 11).

Figure 12 shows example measurements of this system.

CONCLUSION

The features, configurations, and example applications of the AQ2200-136TLS module of the AQ2200 series are discussed above. In addition to this TLS module, the multi-application test system of the AQ2200 series includes the FP-LD module, the DFB-LD module, the optical sensor module, the optical ATTN module, the 10 Gb/s Bit Error Rate Test (BERT) module, the EO module, and the OE module. As mentioned in the Introduction, the infrastructure for optical communication device measurement is now built gradually. The measurement modules of the AQ2200 series will be able to offer suitable measurement environments for many different purposes. ◆

REFERENCES

(1) Iida Rikihiro, Ema Nobuaki, Oota Katsushi, “Development of AQ2200 Multi-Application Test System,” Ando Technical Report, Vol. 73, 2004, pp. 13-17 in Japanese

(2) Inoue Kento, “TOPICS: Compact and Inexpensive 200-nm, Tunable Wavelength Range Tunable Laser Source of Yokogawa Electric Corporation,” OPTCOM, No. 187, 2004, pp. 74-75 in Japanese