# Optical Spectrum Measurement Solutions for Laser Diodes

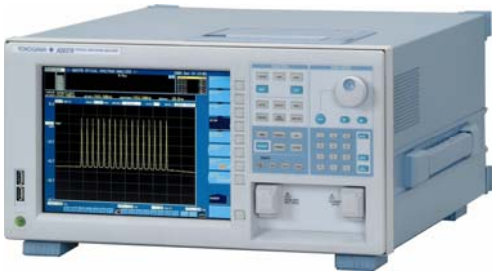
## AQ6370 Optical spectrum analyzer provides powerful spectrum analysis functions for Laser testing.

## 1. Introduction

The optical fiber communication is being widely used in the backbone of the Internet and enterprise communication, etc. In these days, by the spreading of FTTH, optical fiber network is being deployed to each home , and demand of active devices used in the optical network are increasing and performance requirements to them are getting more severe. Optical transmitter and receiver modules indispensable to construct the optical fiber network are called an optical transceiver. The laser diode is used in a transmitter of optical transceiver and typical devices are Fabry-Perot Laser Diodes (FP-LD) and Distributed Feed Back (DFB-LD).

AQ6370 Optical Spectrum Analyzer is fundamental equipment to measure optical spectrum of such active devices and to analyze important parameters of the same quickly and accurately.

This document describes measurement applications of laser diodes (FP-LD and DFB-LD), and explains some technical tips to measure those devices properly using AQ6370 optical spectrum analyzer.



AQ6370 Optical Spectrum Analyzer

## 2. FP-LD (Fabry-Perot Laser Diodes)

In the optical spectrum of FP-LD, two or more peaks exist discretely and, thus FP-LD is used for the short distance optical fiber communication. A typical evaluation item of FP-LD includes Peak wavelength, Mean wavelength, Spectral width and Total power. AQ6370 optical spectrum analyzer can automatically analyze those evaluation items and shows the results.

A typical spectrum of FP-LD is shown in Fig.1, and an example of the analysis results on AQ6370 is shown in Fig. 2.

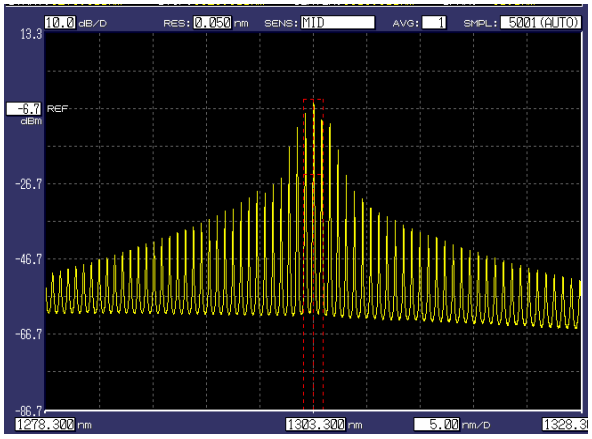



Fig. 1 Optical spectrum of FP-LD


Fig. 2 Analysis results of FP-LD

### ■ Evaluation Items

1) Peak wavelength

It determines a wavelength that the signal has the highest spectral power at from the measured spectrum.

2) Peak level

It determines the highest spectral power in the measured spectrum.

3) Mean wavelength

The spectrum of FP-LD contains plural vertical modes and the mean wavelength is calculated by the following formula taking peaks of multiple vertical modes into account.

$$\lambda \text{ mean} = \frac{\sum_{i=1}^{n} Pi \times \lambda i}{\sum_{i=1}^{n} Pi}$$

Where Pi and l1 in this formula are respectively the peak level and the peak wavelength for each vertical mode. In general only the mode peaks that exceed a pre-defined threshold level referred to the peak level are used for the calculation and the default of the threshold is set to 20dB in AQ6370.

4) Spectral width

Spectral width is determined as broadening of spectrum as related to the mean wavelength. For FP-LD spectrum RMS method is commonly used and its calculation formula is shown below.

$$\triangle\lambda = K \times \sqrt{\frac{\sum_{i=1}^{n} \left[ Pi \times (\lambda i - \lambda \text{ mean})^2 \right]}{\sum_{i=1}^{n} Pi}}$$

Where K is a constant and can be set manually either 1, 2, 2.35, or 3 for any purpose. The default of K is set to 2 in AQ6370. When K is set to 2.35, the spectral width is equivalent to Full Width Half Maximum (FWHM) in which the spectral shape is considered as Gaussian profile.

5) Total power

It is determined by integrating the measured optical spectrum.

6) Mode count

It determines a number of modes that exceed a pre-defined threshold level referred to the peak level.

## 3. DFB-LD (Distributed Feedback Laser Diode)

A typical evaluation item of DFB-LD includes Peak wavelength, Peak level and SMSR. Optical spectrum analyzer can automatically analyze those evaluation items and shows the results.

A typical spectrum of DFB-LD is shown in Fig.3 and an example of the analysis results on AQ6370 is shown in Fig. 4.

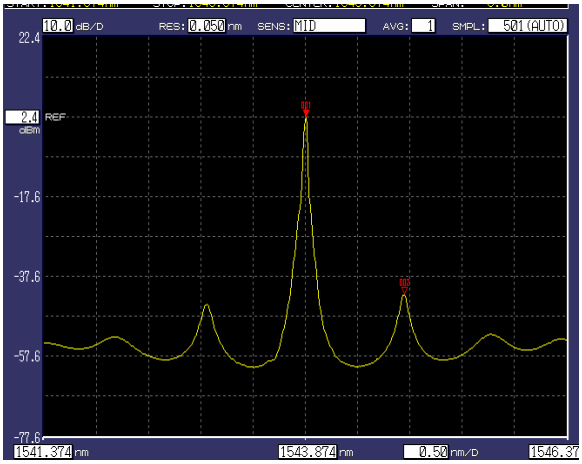



Fig. 3 Optical spectrum of DFB-LD


Fig. 4 Analysis results of DFB-LD

■ **DFB –LD evaluation items**

1) Peak wavelength

It determines a wavelength that the signal has the highest spectral power at from the measured spectrum.

2) Peak level

It determines the highest spectral power in the measured spectrum.

3) SMSR (Side Mode Suppression Ratio)

It represents how the second peak is suppressed, and calculated as a difference in power between the peak and the second peak (either of adjacent peaks).

SMSR= Ppeak – Pside (dB)

4) Mode offset

It is calculated as a difference in wavelength between the peak and the second peak.

■ **Effective way to use the high dynamic range mode**

When evaluating a Source Spontaneous emission (SSE) of External resonance laser for instance, the stray-light of optical spectrum analyzer has to be suppressed enough. The stray-light of the AQ6370 optical spectrum analyzer is highly suppressed even in Normal mode, but yet the high dynamic range mode needs to be used to the reduce stray-light when more than 60 dB of dynamic range is required. Since in the high dynamic range mode the measurement time becomes longer than Normal mode, it shouldn't be used for devices not requiring high dynamic range measurement. When the high dynamic range mode is turned off, AQ6370 is switched over to the normal mode. In the normal mode, both the high sensitivity of -90dBm and the high measurement speed can be achieved.

There are two modes in the high dynamic range mode, SWITCH and CHOP. There are the following features respectively.

| Mode | Features |
|---|---|
| Switch | Fast measurement than CHOP mode |
| Chop | Slower measurement than Switch mode<br>It can continue a measure for a long time without running the offset adjustment of internal amplifier. |

An example of difference in the stray-light level between the high dynamic range more and the normal mode is shown in Fig.5.

In most cases, the SWITCH mode is sufficient to reduce an influence of the stray-light, and it results in shortening the measurement time.

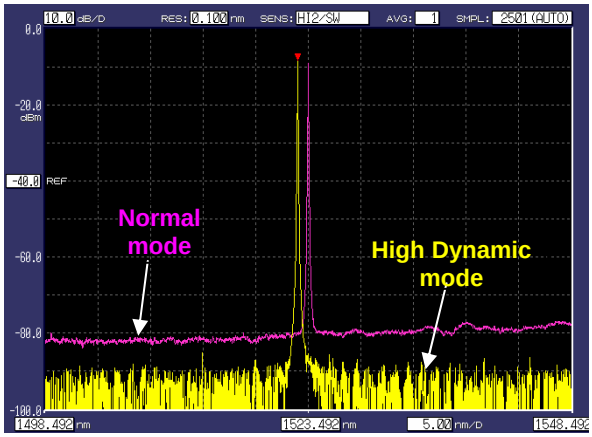



Fig 5 Noise level comparison (High dynamic vs. Normal)

■ **Appropriate wavelength resolution for Laser testing**

When measuring a light source with narrow spectral line width such as FP-LD and DFB-LD, the wavelength resolution of the optical spectrum analyzer has to be narrow enough. Especially when adjacent vertical modes need to be separated, it is recommended to set the wavelength resolution to 1/5 or less of the spacing between vertical modes.

Remarks

The results described in this article are based on the sample measurements. It does not mean that the measurement conditions or testing capabilities of products are guaranteed.

When actual system is measured by above setting, dynamic chirp, chromatic dispersion, modulation format, etc may influence the measurement result and may require a change of measurement settings.