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Measuring a Wide Linewidth Source with the OMH-6700B Series Waveheads

APPLICATION NOTE

ILX Lightwave

Photonic Test and Measurement

Measuring a Wide Linewidth Source with the OMH-6700B Series Waveheads

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Introduction

The OMH-6700B series of optical measurement heads measure wavelength to within ±0.5 nm accuracy for the 6730B series and to within ±1 nm for the 6720B series for narrow linewidth sources. Many sources such as LED's and laser diodes may have wider linewidths, affecting the accuracy of a 6700B series wavehead measurement. As the linewidth increases, the wavehead's measured value drifts from the center wavelength of the source. If a source has a full-width, half-max linewidth of 7 nm, there may be relative errors of as much as ±0.1 nm between the center wavelength of the source and the wavehead reading.

This application note offers a technique to calculate the relative error between the center wavelength of a wide-linewidth source and the reading of a OMH-6700B series wavehead. In addition, results are given for a Gaussian and a non-Gaussian source.

Wavehead Design

The OMH-6700B series waveheads use a unique colored-filter system, along with integrating sphere technology, and single-element photodiodes, to measure wavelength of light sources. Light enters the waveheads and is dispersed by an integrating sphere, after which it is directed through the colored-filter system to the photodiodes (refer to fig. 1). Because transmission through the filter system depends on the wavelength, light passing through the system generates a unique pair of currents in the two photodiodes. The OMM-6810B optical multimeter calculates the ratio of these currents and looks up the current ratio in a calibration table stored in the wavehead, reporting the corresponding wavelength to the user. For an example of such a calibration ratio curve, see figure 2.

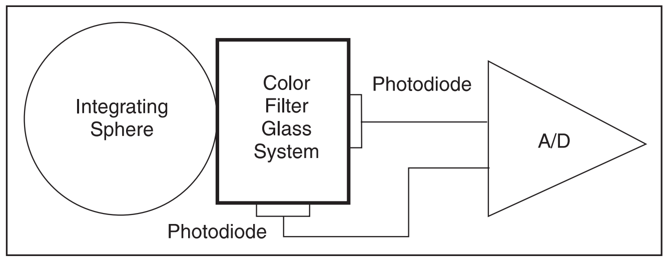

Figure 1.

ILX Lightwave individually calibrates each wavehead. The calibration techniques used to generate the chart of current ratios in the OMH-6700B series can be directly traced to NIST, The National Institute of Standards and Technology (see Application Note No.12 "Calibration and Traceability of ILX Lightwave Optical Power Meters" for more information). ILX Lightwave uses reference standards similar to in-house NIST transfer standards in its calibration station. When used in conjunction with a monochromator, the calibration technique allows the OMH-6700B series to provide accurate power and wavelength measurements from 400 to 1600 nm.

Wide Linewidth Sources

Because the light of many different wavelengths is present in a wide linewidth source, the OMH-6700B series may not measure the source's center wavelength. As the light from a wide linewidth source passes through the colored-filter system, the multiple wavelengths present pass through the system in varying manners. The filter system's transmission depends on wavelength, and each wavelength passes through slightly differently. In addition, semiconductor devices have different responsivity for different wavelengths (see fig. 2). As the various wavelengths hit the photodiode, each produces a current dependent on its wavelength. When light from the wide linewidth source hits the photodiode, instead generating a current directly correlated to a specific wavelength, the light generates a current in the photodiode which is the sum of the currents produced by the different wavelengths present. Thus, the total photodiode current depends on the wavelengths present and the responsivity of the photodiode.

The Error Calculation

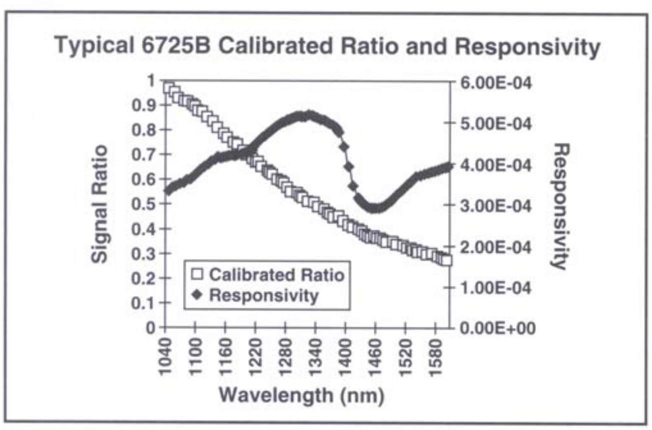

Figure 2.

Assuming a perfect, Gaussian source with a full-width, half-max value of 40 nm, it is possible to make an estimate of the relative error between the center wavelength of the Gaussian source and the OMH-6700B series wavelength reading. Using typical photodiode responsivity curves, one calculates the total current the Gaussian source generates in each photodiode by multiplying the Gaussian source spectrum by the responsivity of the photodiode and summing over wavelength.

$$I_{Total} = \sum (\text{Gaussian Spectrum}) * (\text{Responsivity})$$

Then, after calculating the current produced in each photodetector and taking into account the light filtering processes, it is possible to calculate the current ratio generated by the Gaussian source.

$$\text{Ratio}_{\text{Gaussian}} = \frac{\text{I Photodetector \#1}}{\text{I Photodetector \#2}}$$

The difference between the stored calibration ratio and the calculated Gaussian ratio, when multiplied by the change in the calibration ratio with respect to the known center wavelength, yields the relative error between the center wavelength of the Gaussian source and the wavehead reading.

$$\text{Relative Error} = (\text{Ratio}_{\text{Calibrated}} - \text{Ratio}_{\text{Gaussian}}) * \frac{d(\text{Ratio}_{\text{Calibrated}})}{d\lambda}$$

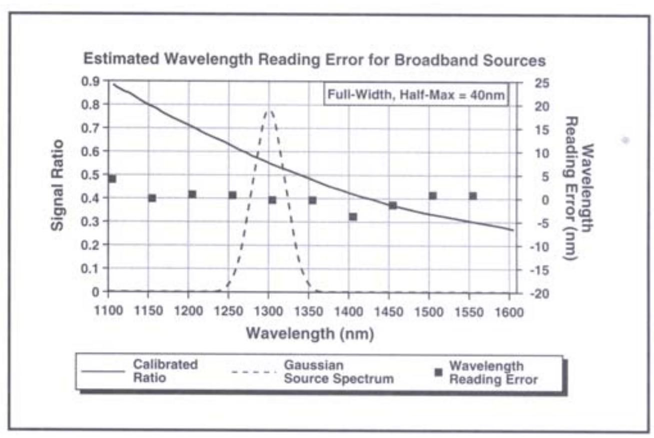

Figure 3.

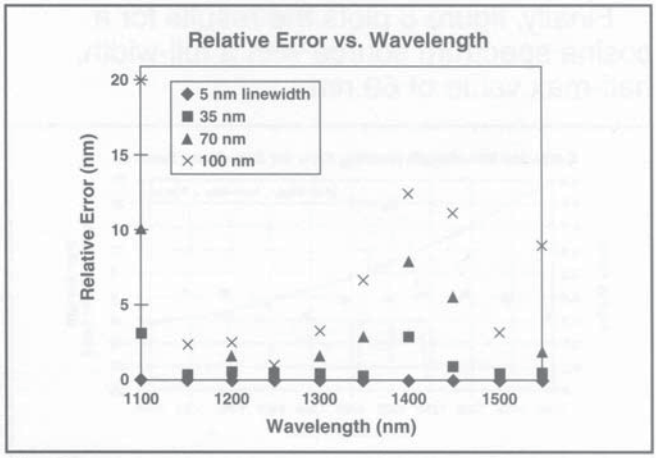

Figure 4.

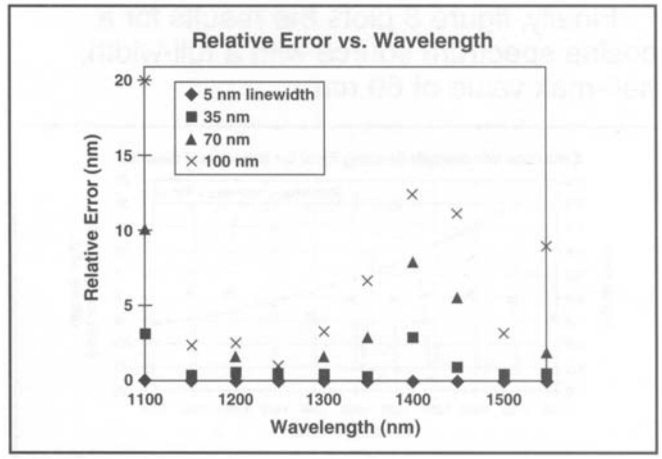

Figure 5.

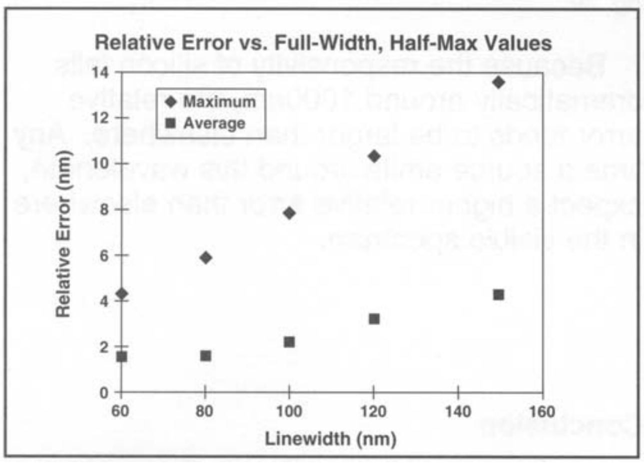

Figure 6.

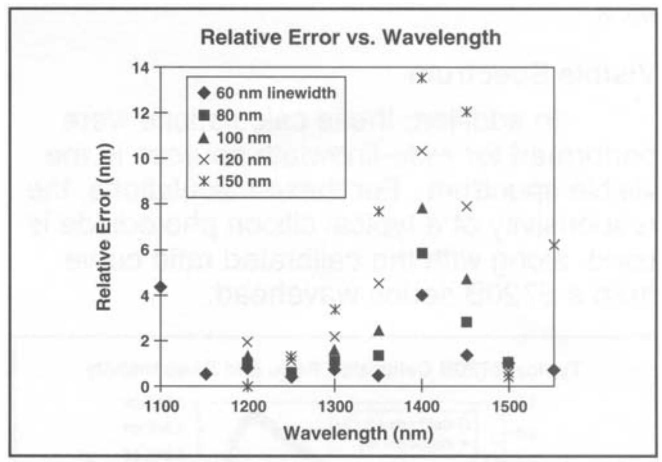

Figure 7.

Results for a Gaussian source with a full width, half max value of 40 nm and a center wavelength of 1300 nm are plotted in figure 3.

Results

The wider the linewidth of a source, the greater the difference between the wavehead reading and the center wavelength. In figure 4, the absolute values of the relative error are plotted vs. linewidth.

However, because the error in reading depends on the responsivity of the detector, it also depends upon wavelength (see fig. 5).

Notice how the relative error is greatest at the wavelengths (such as 1400 nm) where the responsivity's slope is greatest (refer back to fig. 2). The larger relative error around 1100 nm is due to the characteristics of the colored-filter system.

Non-Gaussian Source Results

Repeating the same analysis as above with a cosine spectrum source provides an estimate on the error of the wavehead reading for LED sources. Once again, the source is idealized. In this case, the source is identically zero outside the single cosine peak. Figure 6 plots the absolute values of the relative error against the linewidth of the source. As before, this error also depends upon wavelength. Finally, figure 8 plots the results for a cosine spectrum source with a full-width, half-max value of 60 nm.

Visible Spectrum

In addition, these calculations were performed for wide-linewidth sources in the visible spectrum. For these calculations, the responsivity of a typical silicon photodiode is used, along with the calibrated ratio curve from a 6720B series wavehead.

Assuming cosine spectrums of varying wavelengths and linewidths, the relative errors between the center wavelength of the wide linewidth sources and the 6810B reading are plotted in figure 10. These errors are not plotted as absolute values as they are in previous plots.

Because the responsivity of silicon falls dramatically around 1000nm, the relative error tends to be larger than elsewhere. Any time a source emits around this wavelength, expect a higher relative error than elsewhere in the visible spectrum.

Conclusion

It is possible to estimate the relative error between the 6700B series wavehead readings and the center wavelengths of wide linewidth sources. The 6700B wavehead series measures the power-averaged wavelength of narrow linewidth sources. However, due to the dependence of photodiode responsivity on wavelength, if the source's linewidth is greater than 7 nm, expect the wavehead reading to differ from the center wavelength by ±1 nm or more.

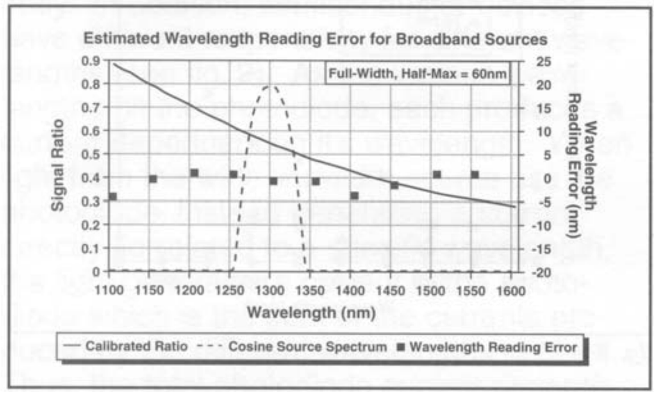

Figure 8.

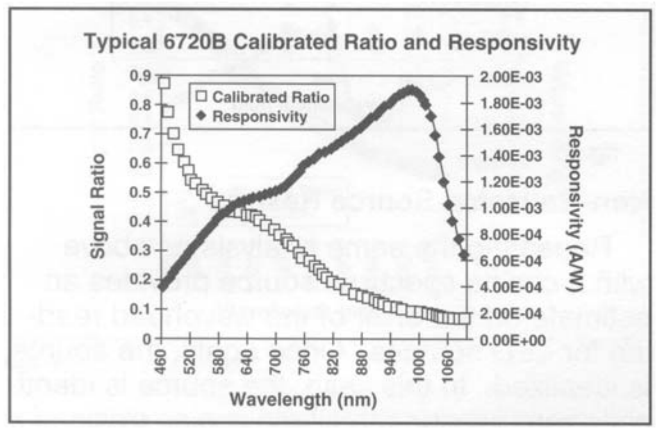

Figure 9.

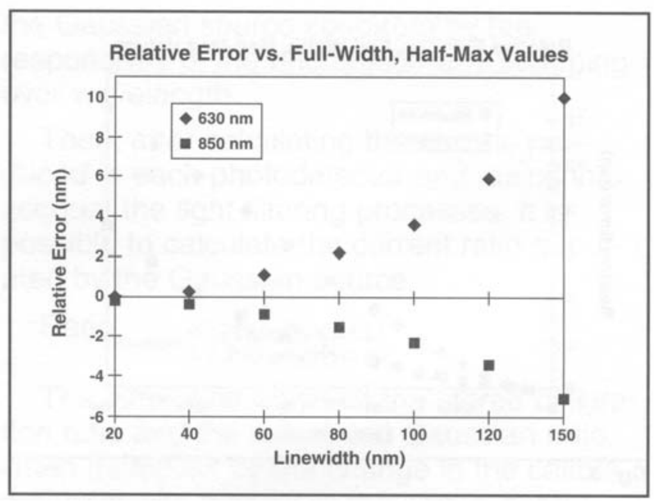

Figure 10.

The following publications are available for download on www.ilxlightwave.com.

White Papers

- A Standard for Measuring Transient Suppression of Laser Diode Drivers
- Degree of Polarization vs. Poincaré Sphere Coverage
- Improving Splice Loss Measurement Repeatability

Technical Notes

- Attenuation Accuracy in the 7900 Fiber Optic Test System
- Automatic Wavelength Compensation of Photodiode Power Measurements Using the OMM-6810B Optical Multimeter
- Bandwidth of OMM-6810B Optical Multimeter Analog Output
- Broadband Noise Measurements for Laser Diode Current Sources
- Clamping Limit of a LDX-3525 Precision Current Source
- Control Capability of the LDC-3916371 Fine Temperature Resolution Module
- Current Draw of the LDC-3926 16-Channel High Power Laser Diode Controller
- Determining the Polarization Dependent Response of the FPM-8210 Power Meter
- Four-Wire TEC Voltage Measurement with the LDT-5900 Series Temperature Controllers
- Guide to Selecting a Bias-T Laser Diode Mount
- High Power Linearity of the OMM-6810B and OMH-6780/6790/6795B Detector Heads
- Large-Signal Frequency Response of the 3916338 Current Source Module
- Laser Wavelength Measuring Using a Colored Glass Filter
- Long-Term Output Drift of a LDX-3620 Ultra Low-Noise Laser Diode Current Source
- Long-Term Output Stability of a LDX-3525 Precision Current Source
- Long-Term Stability of an MPS-8033/55 ASE Source
- LRS-9424 Heat Sink Temperature Stability When Chamber Door Opens
- Measurement of 4-Wire Voltage Sense on an LDC-3916 Laser Diode Controller
- Measuring the Power and Wavelength of Pulsed Sources Using the OMM-6810B Optical Mutlimeter
- Measuring the Sensitivity of the OMH-6709B Optical Measurement Head
- Measuring the Wavelength of Noisy Sources Using the OMM-6810B Optical Multimeter
- Output Current Accuracy of a LDX-3525 Precision Current Source
- Pin Assignment for CC-305 and CC-505 Cables
- Power and Wavelength Stability of the 79800 DFB Source Module
- Power and Wavelength Stability of the MPS-8000 Series Fiber Optic Sources
- Repeatability of Wavelength and Power Measurements Using the OMM-6810B Optical Multimeter
- Stability of the OMM-6810B Optical Multimeter and OMH-6727B InGaAs Power/Wavehead
- Switching Transient of the 79800D Optical Source Shutter
- Temperature Controlled Mini-DIL Mount
- Temperature Stability Using the LDT-5948
- Thermal Performance of an LDM-4616 Laser Diode Mount
- Triboelectric Effects in High Precision Temperature Measurements
- Tuning the LDP-3840 for Optimum Pulse Response
- Typical Long-Term Temperature Stability of a LDT-5412 Low-Cost TEC
- Typical Long-Term Temperature Stability of a LDT-5525 TEC
- Typical Output Drift of a LDX-3412 Loc-Cost Precision Current Source
- Typical Output Noise of a LDX-3412 Precision Current Source
- Typical Output Stability of the LDC-3724B
- Typical Output Stability of a LDX-3100 Board-Level Current Source
- Typical Pulse Overshoot of the LDP-3840/03 Precision Pulse Current Source
- Typical Temperature Stability of a LDT-5412 Low-Cost Temperature Controller
- Using Three-Wire RTDs with the LDT-5900 Series Temperature Controllers
- Voltage Drop Across High Current Laser Interconnect Cable
- Voltage Drop Across High Current TEC Interconnect Cable
- Voltage Limit Protection of an LDC-3916 Laser Diode Controller
- Wavelength Accuracy of the 79800 DFB Source Module

Application Notes

- App Note 1: Controlling Temperatures of Diode Lasers and Detectors Thermoelectrically
- App Note 2: Selecting and Using Thermistors for Temperature Control
- App Note 3: Protecting Your Laser Diode
- App Note 4: Thermistor Calibration and the Steinhart-Hart Equation
- App Note 5: An Overview of Laser Diode Characteristics
- App Note 6: Choosing the Right Laser Diode Mount for Your Application
- App Note 8: Mode Hopping in Semiconductor Lasers
- App Note 10: Optimize Testing for Threshold Calculation Repeatability
- App Note 11: Pulsing a Laser Diode
- App Note 12: The Differences between Threshold Current Calculation Methods
- App Note 13: Testing Bond Quality by Measuring Thermal Resistance of Laser Diodes
- App Note 14: Optimizing TEC Drive Current
- App Note 17: AD590 and LM335 Sensor Calibration
- App Note 18: Basic Test Methods for Passive Fiber Optic Components
- App Note 20: PID Control Loops in Thermoelectric Temperature Controllers
- App Note 21: High Performance Temperature Control in Laser Diode Test Applications

For application assistance or additional information on our products or services you can contact us at:

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