TECH NOTE

Temperature Stability Using the LDT-5948

This technical note illustrates the temperature control stability of an LDT-5948 through measurement of the output wavelength of a DFB diode laser. This test was performed in a typical laboratory environment, as well as an environmental chamber, to show how normal environmental fluctuations from air conditioning, movement of people, etc. can affect temperature measurements.

INTRODUCTION

Measurement of a diode laser's output wavelength is a highly accurate method of monitoring the chip temperature because of the relatively large wavelength shift that occurs when the laser temperature is varied. A typical DFB laser exhibits a $\Delta\lambda / \Delta T \cong 0.11$ nm/^{o}C. With a slope of this magnitude, milliKelvin changes in temperature can be measured with a suitable wavemeter.

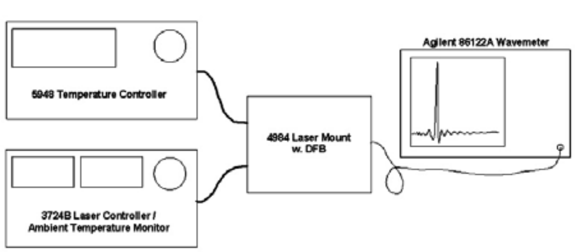

FIGURE 1 – Test Setup

MEASUREMENT SETUP

A schematic of the test setup is shown in Figure 1. The laser source chosen was a typical 20mW 1556 nm DFB laser mounted in an LDM-4984 butterfly mount. The laser drive current was provided by an LDC-3724B laser controller configured to operate in constant current mode. A thermistor for monitoring ambient temperature was connected to the sensor input of the 3724B's temperature controller. The output of the LDT-5948 being tested was used to control the internal temperature of the laser and set to operate at 20^{o}C. The 5948 has full PID tuning capability with an auto-tune feature. The PID constants for this experiment were determined by using the auto-tune feature.

Wavelength was measured using an Agilent® 86122A wavemeter with sub-picometer resolution and accuracy.

During the tests, all instruments were queried via GPIB every five seconds for 24 hours to obtain temperature and wavelength data. The instruments were not allowed to warm up prior to the start of data collection so that any warm up characteristics could be captured. The results are shown in Figures 2 and 3.

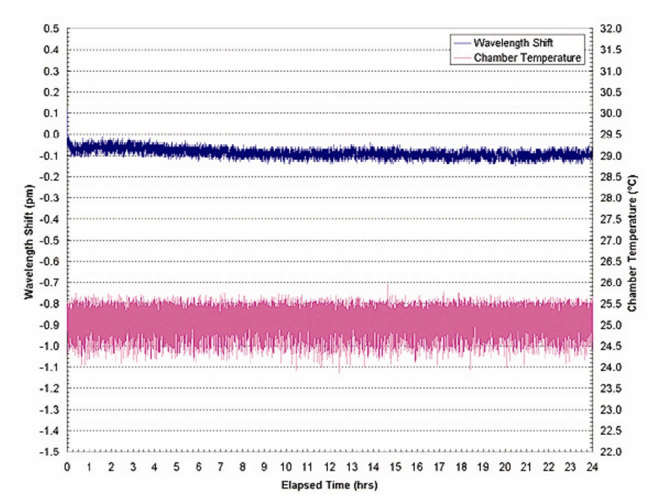

FIGURE 2 – Wavelength Stability

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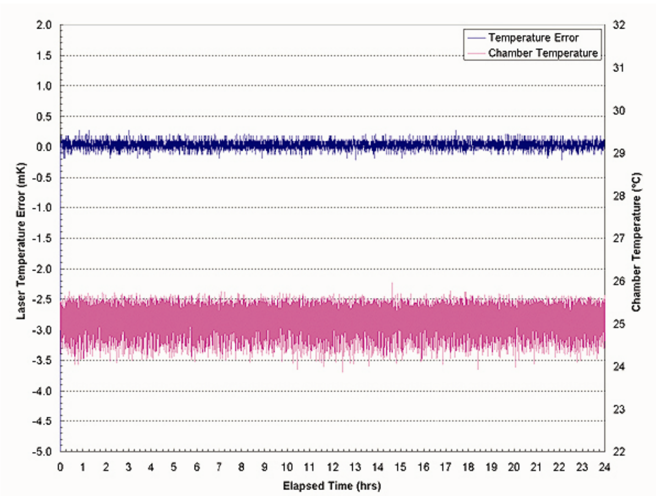

FIGURE 3 – Temperature Error

TEST RESULTS

After allowing for equipment warm up, the wavelength shift was less than $\pm$0.1 pm over a 24-hour span. Also, the difference between the measured laser temperature and the setpoint temperature remained within $\pm$0.2 mK over the same time span. These minute wavelength shifts versus temperature coincide with those found at the macroscopic level, namely ~0.1 nm/^{o}C.

In addition to monitoring performance in an environmental chamber where temperature can be held to within $\pm$0.5^{o}C of the setpoint temperature, the same tests were run with all equipment sitting in an open laboratory environment. This data is summarized in Figures 4 and 5.

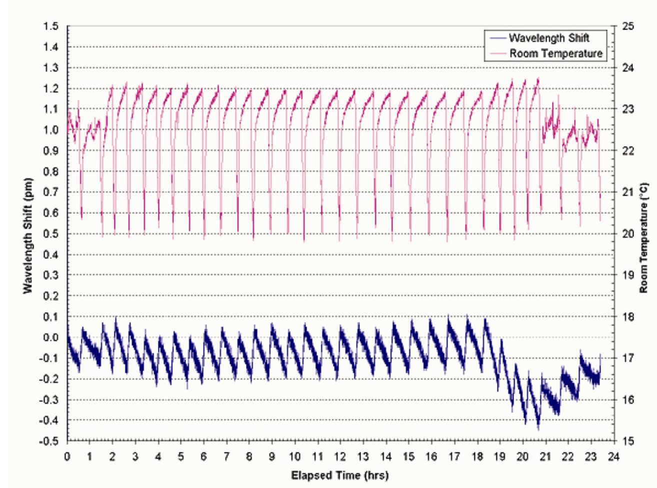

FIGURE 4 – Laboratory Environment Wavelength Stability

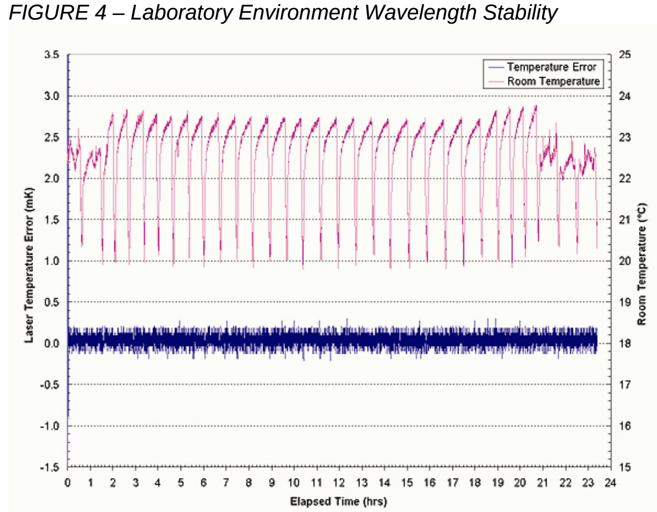

FIGURE 5 – Laboratory Environment Temperature Error

The most obvious difference between the two sets of data is the cycling caused by the room's air conditioning. Blasts of cold air cool the laser which causes a response by the temperature controller resulting in sudden wavelength shifts on the order of $\pm$0.1 pm. On top of the oscillations is an average wavelength shift of 0.3 pm cause by a shift in the average room temperature.

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It is interesting to note that the plot of temperature error (the difference between measured temperature and setpoint temperature – shown in Figure 5) shows none of this variation. This is attributed to the fact that the thermistor attached to the die inside the laser package is not mounted to the exact same point as the laser chip itself. This difference in positioning and thermal resistance, albeit small, is enough to cause this disparity.

Finally, a competitor's temperature controller was operated under similar laboratory conditions in order to compare performance. This instrument has a full PID temperature control loop like the 5948, but with no auto-turn feature. Because of this, the PID values were empirically determined to provide quick temperature control with minimal oscillations. A comparison of the two units' temperature errors is shown in Figure 6.

The LDT-5948 has a temperature error five to ten times smaller than the competitor's instrument when operating under the same conditions. In terms of temperature control stability, this error can lead to increased temperature uncertainties which may be problematic in wavelength critical applications.

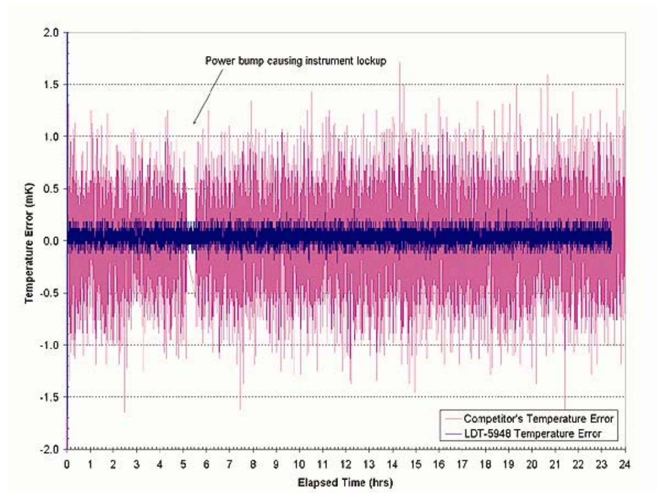

FIGURE 6 – Temperature Error Comparison