High Precision Frequency Locking System for Dual-DFB Lasers in UDWDM-PON

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***Abstract*—We demonstrate a high precision frequency locking system for dual-DFB lasers, which makes the frequency difference between two lasers less than ± 80 MHz when the ambient temperature varies from 10 °C to 60 °C.**

Keywords—PON, DFB Lasers, Frequency Locking, ADC, FPGA

I. Introduction

Ultra-dense wavelength division multiplexing passive optical network (UDWDM-PON) is considered as a promising access technology for the next-generation access network. It requires a very stable relative frequency difference between the local laser in the new optical network unit (ONU) and the signal laser in the optical line termination (OLT) [1,2]. System block diagram of UDWDM-PON is shown in Fig.1.

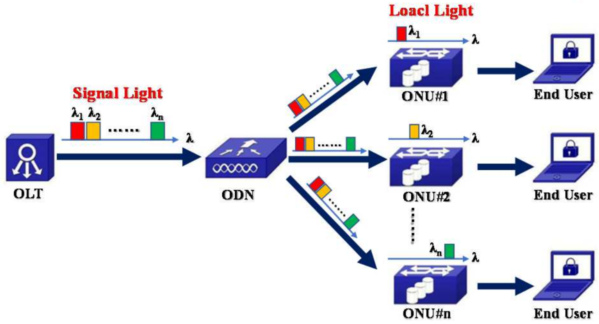
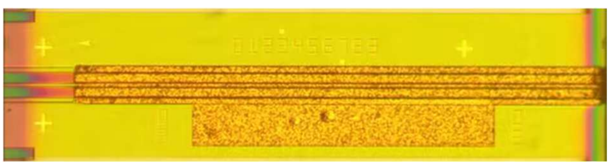
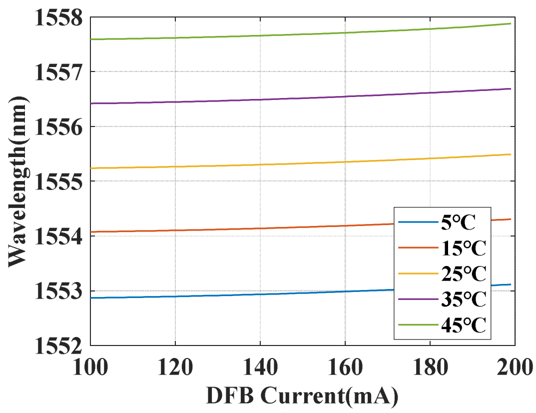


Fig. 1 System block diagram of UDWDM-PON

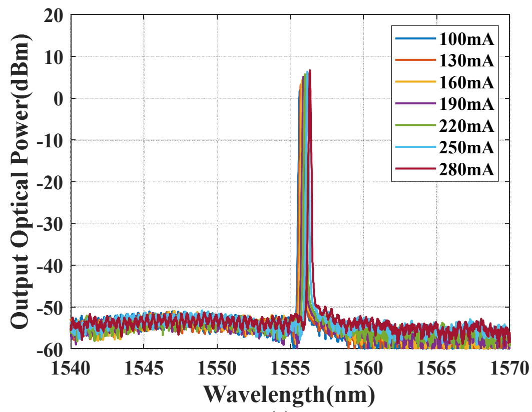
This paper demonstrates a high precision frequency locking system for dual-DFB lasers. Figure 2 (a) shows the photo of the DFB laser chip [3,4]. Figure 2 (b) and (c) show the wavelengths and spectra of the laser at different currents and temperatures. The output wavelength of the laser is positively correlated with the operating current and temperature. By feedback adjusting the temperature and current of lasers, the frequency difference between the signal laser and the local laser can be made as small as possible. Figure 2 (d) compares the wavelength jitter of signal laser under different temperature control resolution conditions. We have designed a high-precision proportional-integral-derivative (P-I-D) laser temperature control circuit with 16-bit resolution, which makes the wavelength jitter of a single laser less than 0.6 pm.



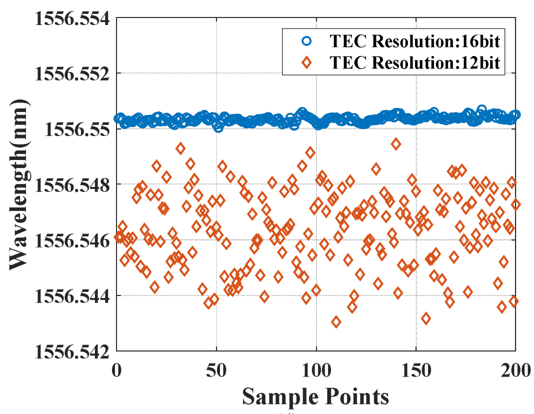
(a)



(b)



(c)



(d)

Fig. 2 (a)The photo of the DFB laser chip; (b) Relationship between wavelengths and currents at different temperatures; (c) Spectra at different currents; (d) Wavelength jitter at different TEC resolutions.

II. System Design

Figure 3 (a) and (b) show the block diagram and photo of the frequency locking system respectively.

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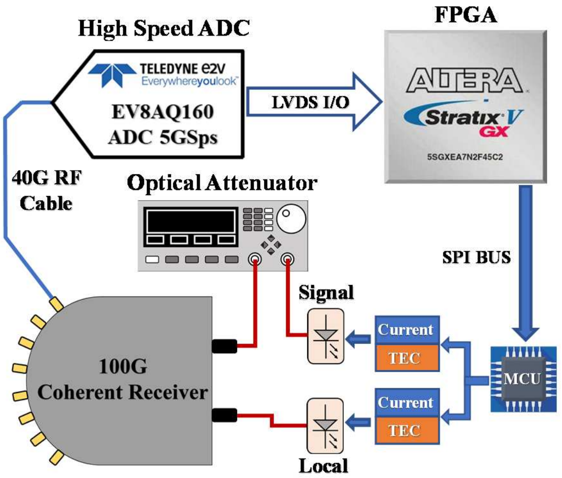


(a)

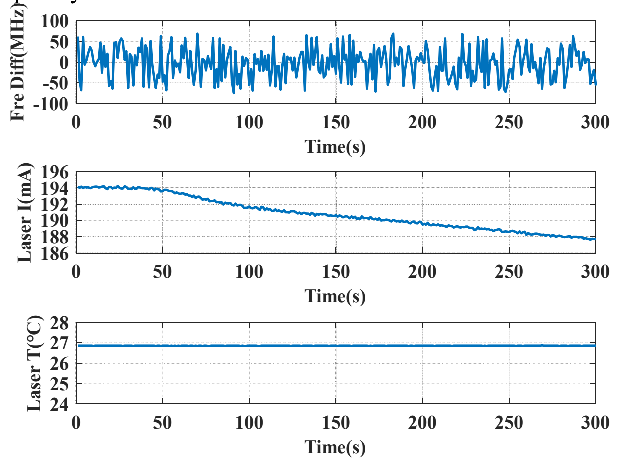
(b)

Fig. 3 (a) The block diagram of the frequency locking system; (b) The photo of the frequency locking system.

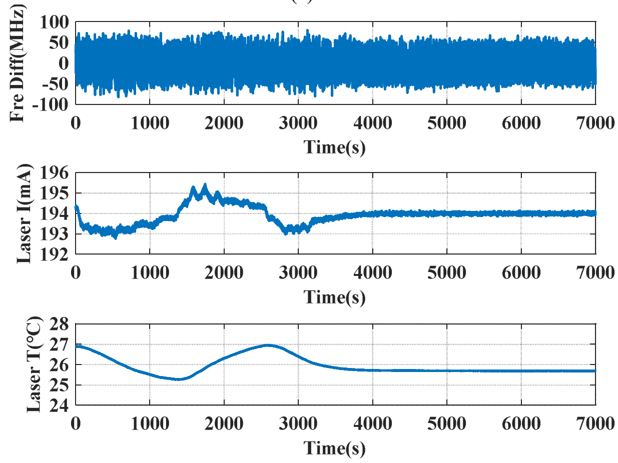
In this paper, coherent optical receiver is used to beat the local laser and the signal laser. The electrical signal carrying the frequency difference information of two lasers are sampled by the high-speed analog-to-digital converter (ADC). The digital signals are transmitted to the field programmable gate array (FPGA) through low-voltage differential signaling (LVDS) lines. The FPGA performs digital signal processing (DSP) algorithm and encodes the frequency difference into a serial peripheral interface (SPI) protocol which is received by the microcontroller unit (MCU). MCU feedback controls the temperature and current of the local laser to achieve frequency locking to the signal laser.

III. Test Result

In order to ensure the stable operation of the system at different ambient temperatures, the control circuit and the local DFB laser are placed in the high and low temperature test box while the signal laser is placed outside. The ambient temperature is cycled between 10 ℃ and 60 ℃. Figure 4 (a) shows that when the temperature of the laser is set constant, the frequency locking is realized only by adjusting the current. The current will continue to decrease when the ambient temperature rises to compensate for the frequency change, which will seriously affect the stability of the laser output power. Figure 4 (b) shows the test results after designing a P-I-D algorithm to jointly adjust the temperature and current. In the whole process of temperature rise and fall, the maximum current jitter of the laser does not exceed ± 1.5 mA. The current is compensated by changing the laser temperature and finally returns to the initial value of 194 mA with the frequency difference still within ± 80 MHz .



(a)



(b)

Fig. 4 (a) The result of adjusting current only; (b) The result of adjusting current and temperature jointly.

IV. Conclusion

In conclusion, we experimentally demonstrated a high precision and stable dual-DFB laser frequency locking system. When the operation ambient temperature of the system is cycled between 10 ℃ and 60 ℃, the frequency difference between the two lasers can be stabilized at ± 80 MHz, and the injection current jitter of the controlled local laser is less than ± 1.5 mA. It provides a solution for maintaining stable relative frequency difference between ONU local laser and OLT signal laser in UDWDM-PON system.

References

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