Injection locked 반도체 레이저를 이용한 광학적 Single Sideband 생성
Generation of Optical Single Sideband Using an Injection Locked Semiconductor Laser

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Abstract

A novel optical single sideband (SSB) modulation technique using an injection-locked semiconductor laser is proposed. The transformation of double-sideband signals into optical SSB is realized using locking characteristics of a semiconductor laser. It is experimentally shown that the resulting optical SSB signals do not suffer from fiber dispersion.

Millimeter-wave (mm-wave) wireless access systems have attracted attentions in broadband radio services such as mobile communication, intelligent transportation system, and indoor wireless LAN, since the utilization of the mm-wave frequency ensures not only large transmission bandwidth but also effective frequency reuse. [1] For the delivery of mm-wave signals, the fiber-optic technique is a powerful solution mainly because of optical fibers having low loss, large bandwidth and immunity to electromagnetic interference. A simple approach to transmit mm-wave signals over fiber-optic links is to use double-sideband (DSB) modulation with high-speed intensity modulators. [2]

The DSB-modulated signals have two sidebands separated by the desired mm-wave frequency f_{mm} from the optical carrier in the optical spectrum. As they propagate through dispersive optical fibers, two sideband signals experience disparate phase-shifts. Whenever the relative phase difference between two sidebands becomes π, the photo-detected signal powers are greatly suppressed. [2] In order to overcome this problem of DSB-modulated signal, optical single sideband (SSB) modulation is required.

In this paper, we propose a novel optical SSB generation scheme using an injection-locked semiconductor laser (SL), where the SL under the DSB-modulated light (DSB-ML) injection acts as an optical filter, as shown in Fig. 1. The conceptual diagram of the proposed scheme is illustrated in Fig. 2. An injection-locked SL with the gain and filtering characteristics transforms the input DSB-ML into SSB. In Fig. 2, the dotted arrows represent the wavelength of the free-running SL, and the shaded areas represent the locking range within which the injected optical signals have optical gain. When one sideband at the shorter wavelength of the DSB-ML is located within the locking range as shown in Fig. 2(a), the injection-locking occurs and the sideband at the shorter wavelength obtains the largest optical gain in the SL. On the contrary, other DSB-ML modes outside the locking bandwidth become suppressed. As a result, only two dominant modes are realized and the optical SSB generation is achieved. When two or even three DSB-ML optical modes are located within the locking range as shown in Fig. 2(b), injection-locking to each mode is possible but the mode at the longer wavelength gets the largest optical gain. Consequently, the optical SSB generation is again achieved.

Experiments were performed with a set-up shown in Fig.1. The optical spectrum of DSB-ML modulated at 30GHz is shown as input in Fig. 2, where each sideband is separated by 30 GHz from the optical carrier. The output optical spectra in Figs. 2(a) and 2(b) are the measured results for the resulting optical SSB signals. In both cases, the desired sidebands for SSB are larger than unwanted sidebands by more than 20 dB. In addition, photo-detected 30 GHz signal powers were measured as function of fiber transmission length and the results are shown in Fig.3. Unlike the DSB-modulated signal, the optically SSB modulated signals are not influenced by fiber dispersion as shown in Fig. 3.

In conclusion, a novel optical SSB modulating technique using an injection-locked semiconductor laser has been proposed and successfully demonstrated. The proposed method has the benefit that it can be easily implemented by simple addition of a temperature-controlled DFB laser.

[1] H. Ogawa, et al., "Millimeter-wave fiber optics systems for personal radio communication," *IEEE Trans. Microwave Theory Tech.*, vol. 40, no. 12, pp.2285-2292, 1992.

[2] G. H. Smith, et al., "Overcoming chromatic-dispersion effects in fiber-wireless systems incorporating external modulators," *IEEE Trans. Microwave Theory Tech.*, vol. 45, no. 8, pp.1410-1415, 1997.

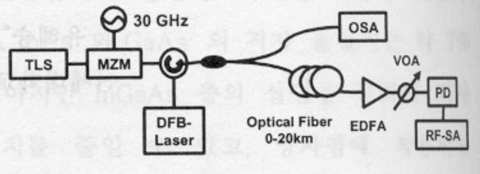

Fig.1 Experimental setup

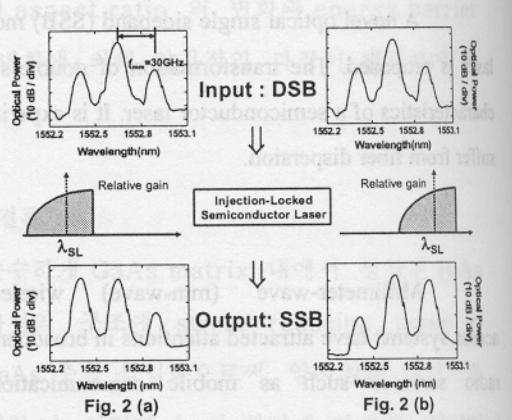

Fig. 2 Conceptual diagram and measured optical spectra for input DSB modulated light and output SSB for the case locked to the sideband at the shorter wavelength (a) and for the case locked to the sideband at the longer wavelength (b)

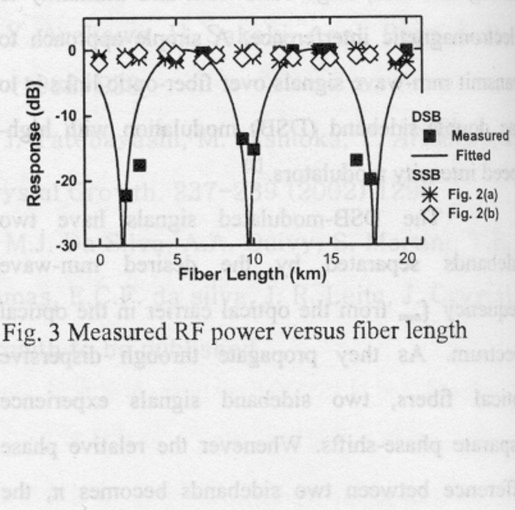

Fig. 3 Measured RF power versus fiber length