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Multi-carrier Light Generator Using Phase Modulators and Chirped Fiber Bragg Grating

Takashi Yamamoto*, Tetsuro Komukai, Kazunori Suzuki, and Atsushi Takada

*NTT Access Network Service Systems Laboratories
1-7-1, Hanabatake, Tsukuba, Ibaraki, 305-0805 Japan
Tel. +81 29 868 6114, Fax +81 29 868 6440
Email: yamamoto.takashi@ansl.ntt.co.jp

NTT Network Innovation Laboratories
1-1, Hikari-no-oka, Yokosuka, Kanagawa, 239-0847 Japan

Abstract — This paper describes a muiti-carrier light generation technique that utilizes a CW light source, two phase modulators and a chirped fiber Bragg grating (FBG). By adopting a chirped FBG as a dispersion medium instead of a long normal dispersion fiber, we can increase the stability of the optical output spectrum and reduce the size of the muiti-carrier light generator. We have built a prototype of the multi-carrier light generator with this configuration. The prototype apply a 25 GHz sinusoidal phase modulation with a modulation index of $\pi/4$, and a dispersion with D = 98 ps/nm to a CW light followed by a 25 GHz sinusoidal phase modulation with a modulation index of 9.7π. We have obtained 61 carrier-light with the power deviation of less than 8 dB.

A multi-carrier light generator, which emits many optical line spectra arranged with an equal frequency interval, is expected to play an important role to realize flexible and robust photonic networks. Several configurations have been proposed for a multi-carrier light generator; a phase modulator in an optical resonator [1], the combination of an optical pulse generator and a nonlinear fiber [2], and the combination of a CW light source, a phase modulator, and a Mach-Zehnder intensity modulator [3,4]. We had proposed a novel configuration for a multi-carrier light generator, where a CW light source, two phase modulators, and a dispersion medium are used [5]. A 5-km long normal dispersion fiber was used as the dispersion medium and was inserted between the two phase modulators. In this configuration, it is important to suppress the timing change between the two phase modulations to stabilize the whole optical spectrum of multi-carrier light. To avoid the timing change, it is necessary to shorten the fiber length between the two phase modulators and suppress the effect of temperature change. In this paper, we describe a multi-carrier light generator in which a chirped FBG is used as a dispersion medium instead of the long normal dispersion fiber. By adopting the chirped FBG, we can increase the stability of the optical output spectrum, and reduce the size of the multi-carrier light generator.

Fig. 1 shows a block diagram of our proposed multi-carrier light generator. A CW light source, a 1st phase modulator, a chirped FBG, and a 2nd phase modulator are connected serially. First, a sinusoidal phase modulation with a frequency of f_m and a modulation index of $\pi/4$ is applied to a CW light. Then the chirped light is coupled into the chirped FBG whose group velocity dispersion (GVD) is set at $\pm 1/(4\pi f_m^2)$. The output of the chirped FBG is coupled into the 2nd phase modulator, and a sinusoidal phase modulation with a large modulation index is applied. The calculated optical spectrum at the 2nd modulator output for a modulation index of 10 π is also shown in Fig. 1. A multi-carrier light with an equal frequency interval of f_m is generated. The number of the carrier light is nearly proportional to the modulation index of the 2nd phase modulation. The spectral flatness is preserved for any modulation index of the 2nd phase modulation.

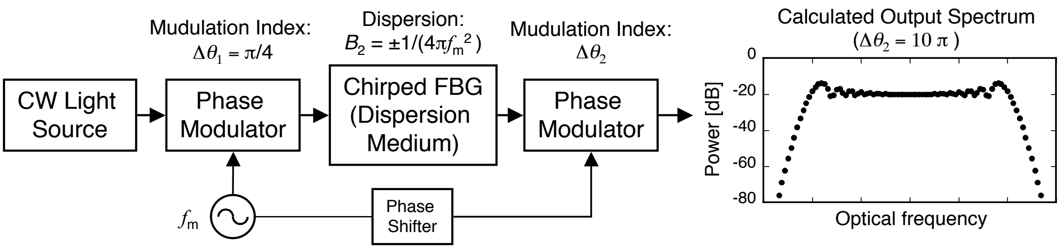

Fig. 1 Block diagram and calculated output spectrum of the proposed multi-carrier light generator.

Fig. 2 Appearance of prototype multi-carrier light generator.

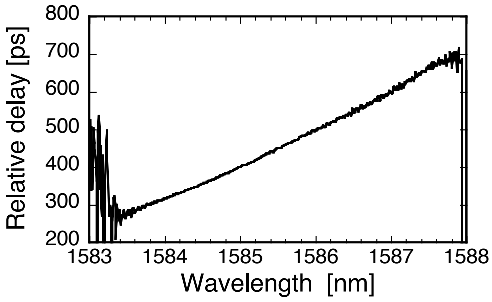

Fig. 3 Delay characteristic of chirped FBG.

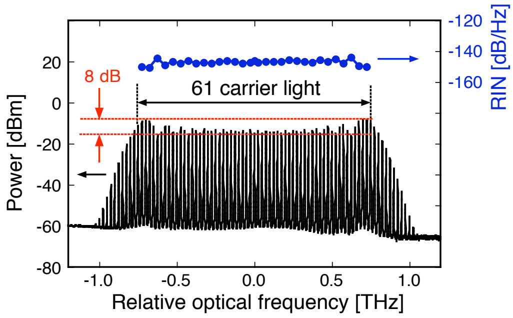

Fig. 4 Optical spectrum and RIN characteristic of the prototype multi-carrier light generator.

We have built a prototype of the multi-carrier light generator with this configuration. Fig. 2 shows the appearance of the prototype. The prototype contains phase modulators, a chirped FBG, an EDFA, and a 25/50 GHz interleaver. By injecting a CW light (λ = 1585.8 nm) and a 25 GHz sinusoidal RF signal into the prototype, multi-carrier light with 50 GHz interval is obtained.

Fig. 3 shows the delay characteristic of the chirped FBG used in the prototype. The delay linearly changes with the wavelength and the dispersion at the CW light wavelength is D = 98 ps/nm.

Fig. 4 shows the optical spectrum and the relative intensity noise (RIN) characteristics of each carrier light measured at the 2nd phase modulator output. We can see that 61 carrier-light with the power deviation of less than 8 dB was obtained. By adopting a chirped FBG in place of a long normal dispersion fiber, the fiber length between the two phase modulators was reduced to less than 10^{-3} and the power stability of each carrier light was significantly improved. The RIN of each carrier light was less than -140 dB/Hz.

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References

[1] M. Kourogi et al., IEEE J. Quantum Electron, vol. 29, no. 10, pp. 2693-2701, October 1993.
[2] E. Yamada et al., Electron. Lett., vol. 37, no. 25, pp. 1534-1536, December 2001.
[3] M. Fujiwara et al., J. Lightwave Tech., vol. 21, no. 11, pp. 2705-2714, November 2003.
[4] M. Sugiyamaet al., ECOC2004, Tu3.4.3, September 2004.
[5] T. Yamamoto et al., F-1, AP-MWP2006, Kobe, Japan, April 2006.