URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Generation of ultralow-phase-noise millimeter-wave signal using an electro-optics-modulation comb

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Future wireless telecommunications and coherent radar systems will use the millimeter-wave (MW) band. For achieving these applications, the phase-noise reduction of signal generator (SG) will be important. Several low-phase-noise MW generation methods based on photonic technologies [1] have been reported. Since these methods need a laser cavity, the repetition frequency is almost fixed, and its tunable range is narrow. We show the novel method to greatly reduce the phase noise of standard SGs. In general, the phase noise of a SG becomes larger as the MW frequency increases. In this work, we show that the phase noise of a standard SG can be reduced using an electro-optics-modulation (EOM) comb [2].

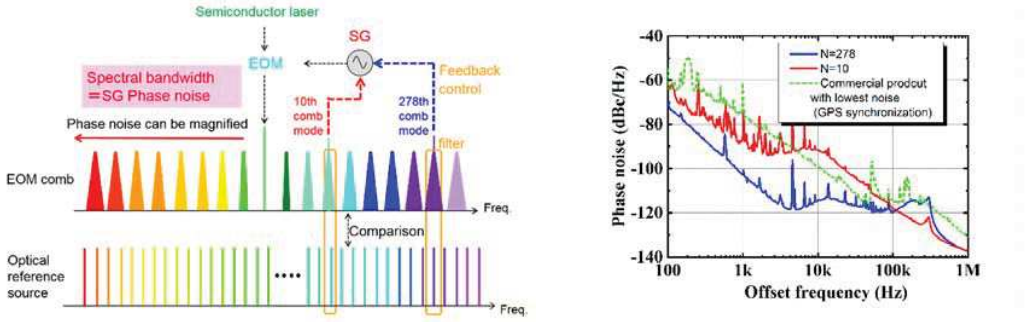

Figure 1. (a) Our concept of low-phase-noise MW generation. (b) Dependence of experimental phase noise of the 25 GHz signal from an SG on the reference comb mode number.

To date, we found that as the separation from a CW semiconductor laser for a seed source, the phase noise of each mode of EOM comb increases [3]. The phase noise of EOM comb is mainly originated from an SG driving EOMs. In this paper, by using the EOM comb as a phase noise booster and feeding the phase noise information into the SG, we have achieved in greatly reducing the phase noise of SG [see Fig. 1(a)]. Our laser system generates an optical pulse train at 25-GHz. The phase and intensity of the light from a CW LD with a center wavelength of 1552 nm are modulated with six conventional phase modulators driven by the SG at a modulation frequency of 25-GHz. By using a 10-m-long highly nonlinear fiber, the supercontinuum light is generated in the range from 1450 to 1700 nm. The SC light and the mode-locked fiber laser are combined in an optical coupler and then selected one comb line with a bandpass filter. Finally, the phase noise of the SG can be reduced by feeding the interference signal between them into the voltage-controlled-oscillator inside the SG. Figure 1(b) shows that the phase noise at 25 GHz can become lower as the comb mode number of the EOM comb increases. The phase noise obtained by using the 278th comb mode number at the offset frequency of 5-kHz and 100-kHz can be lowered to -118 dBc/Hz and -120 dBc/Hz, respectively. We demonstrated that low-phase-noise MW could be generated from the standard SG by using the EOM comb.

1. T. M. Fortier et al. *Nat. photon.*, **5**, 2011, pp. 425-429, doi:10.1038/nphoton.2011.121.
2. A. Ishizawa et al., *Sci. Rep.*, **6**, 2016, pp. 24521, doi:10.1038/srep24621.
3. A. Ishizawa et al., *Opt. Express*, **21**, 2013, pp. 29186-29194, doi:10.1364/OE.21.029186.

Acknowledgements
This work was supported by JSPS KAKENHI Gant Numbers JP17H02803 and JP16H04379.