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Broadband High Extinction Ratio Modulator for Optical Two-Tone Signal Generation

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Abstract A high extinction ratio Mach Zehnder Modulator (MZM) is a key device for generating a pure optical two-tone signal. Characteristics of the high extinction ratio modulators were improved. A half-wavelength voltage was reduced down to 4.1 V_{pp} and a bandwidth (BW) was extended up to 27 GHz. A novel bias control method of the modulator was also developed.

Keywords Mach-Zehnder modulator, millimeter-wave Generation, two-tone stimulus signal

1. Introduction

An optical two-tone signal is a promising method for high spectral purity Millimeter-wave (MMW) signal generation. Concepts of harmonic generation using a MZM were proposed decades ago, however, asymmetry of the transfer curve, excessively high drive voltage and difficulty of bias control have been technical problems. A high-extinction rate modulator of dual-parallel MZM structure had solved the problem of asymmetry [1]. This paper reports our developments to solve the remaining problems.

2. Broadband Low Drive-Voltage Modulator

We have provided conventional dual-parallel MZMs as a Frequency-Shift-Keying modulator. Specifications for a half-wavelength voltage at 10 GHz and a -3 dB optical BW were 8 V_{pp} and 10 GHz, respectively. The fairly high-end drivers have been required for generation of W-band signal.

For the design of broadband $LiNbO_3$ modulators, there is a tradeoff relation between characteristic impedance and electro-optic efficiency which is restricted by overlap integral factor between RF and optical field [2]. The impedance of a modulator in MMW generation application is less severe issue than in digital baseband transmission because the modulating signal is single tone. Thus, we used a design to enhance the overlap integral factor. The modulators were fabricated by applying some micro-fabrication techniques used in production lines. Table.1 shows specifications of the developed modulator. The voltage was reduced down to a half of the conventional one and the BW was extended to over 25 GHz. Optical insertion losses was 7dB, almost same as the conventional one.

Table 1 Specification of High-Extinction Ratio MZM

Spec.	Bandwidth	Vπ @ 10GHz
Conventional Product T·FSX1.5-10	>10GHz Typ. 16 GHz	8.0V
Developed modulator	>25GHz Typ. 27 GHz	4.1V

3. Bias Control method

Optical band-pass filters (BPFs) have been used for monitoring bias conditions. However BWs of optical BPFs is too broad to monitor the conditions if modulating frequency is scanned down to 10 GHz. Moreover, thermal control of optical BPFs is required for precise detection of the bias. Thus, we developed a heterodyne detection method using a phase modulator and eclectic BPFs instead of optical BPFs [3]. Fig.1 shows optical spectrums controlled by the method. Unwanted spurious peaks were well suppressed without thermal control of components.

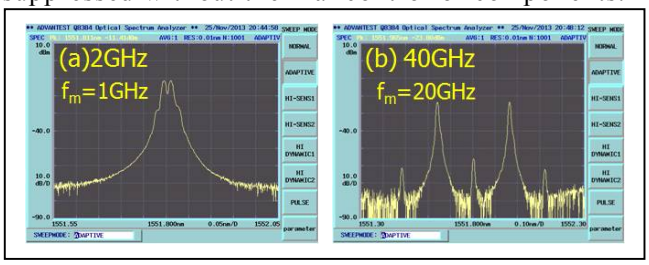

Fig. 1 Optical spectrums of tow-tone signal. a) 2GHz b) 40GHz

4. Conclusion

Characteristics of the modulator have been improved remarkably. The bias control method without thermal control of optical components has been developed. The modulator and the control method will help to solve the remaining problems.

Acknowledgments

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