Nonlinear Distortion Compensation of LD using Predistorter

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Abstract The transfer function of laser diode (LD) for multi-carriers is different depending on the order of IM signals. In this paper, a new type of predistortion linearizer to reduce nonlinear distortion components of LD is proposed, where the individual component of IMD is removed respectively. The proposed method improves C/I ratio of LD (@Po=-19.4dBm) by 21.92dB at IMD_3 and 8.45dB at IMD_5 with two-tones at 877.5MHz, 882.5MHz, respectively

1. INTRODUCTION

In 1970, the era of low loss, long wavelength and optical communication was opened by the success of development of laser. Recently optical amplifier and optical transmission techniques have been conducted for low loss and broadband transmission of signals. Optical amplifier is essential item for physical expansion of the optical communication network. In case of microwave signal transmitting using optical communication network, DFB (Distributed Feedback) laser diode is widely used for modulating optical signal. In modulating process, intermodulation distortion components in microwave band is generated because of nonlinear characteristics of DFB laser diode. Hence this nonlinear characteristic of DFB laser limits the signal level of transmitting microwave signal.

Generally, the transfer function of laser diode (LD) for multi-carriers is different depending on the order of IM signals. In this paper, a new type of predistortion linearizer to reduce nonlinear distortion components of DFB LD is proposed, where the individual component of IMD is removed respectively. The designed predistorter can remove not only the 3rd but also the5th and the7th intermodulation distortion signals.

2. THE MAIN SUBJECT

To analyze the nonlinear characteristics of the active circuit, power series that represents relation between input signal (Vo) and output signal are usually used as below.

$$v_0 = a_1 v_i + a_2 v_i^2 + a_3 v_i^3 + \cdots \qquad (1)$$

If input signal consist of two-tone signals, then, intermodulation distortion signals occur so near the operating channel is difficult to remove them with filter. Among these intermodulation signals, generally the magnitude of the 3rd order is larger than that of any other signals. But when operated near 1dB compression point, the magnitude of higher order distortion components then the 3rd order can't ignore. To compensate nonlinear signal of DFB LD, individual order controlling predistorter is located in front of LD. Once RF signals are fed into preditorter, then there are intermodulation signals besides carrier signals at output port. Carriers as well as predistortion signals are modulated in LD, and then predistoted modulation signals would be cancelled

with intermodulation distortion signals. In the case of previous optical communication, there were many tries to remove only the 3rd IMD [2]. Although the 3rd distortion component is removed, the 5th distortion component in the operating channel can't ignore. So if the 3rd and more than the 5th order distortion components reduce simultaneously, then communication quality would be increased effectively. Fig. 1 shows the proposed predistortion circuit and optic communication system and predistotion mechanism of LD.

Optical communication system consists of a laser diode as laser source, an optical fiber as transmission agent, and photo detector as receiver. Fig. 2 shows the nonlinear distortion characteristic of LD. Fig. 3 is the curve of optic-current of laser diode. If the laser diode is directly modulated, IMD is generated by the gain-saturation phenomenon. As the current amount of laser diode grows large, optical output power does not increase linearly and saturated. Therefore it may cause the magnitude and phase distortion. Fig.4 shows the block diagram of the proposed predistorter. When input signals consist of two-tone CW signals, input signals are separated into main path and sub path by the wilkinson divider. ALC (Automatic Level Controller) is used to maintain constant magnitude of signals in operating power range. Harmonic generator (HG) generates intermodulation signals and bias-controlled amplifier generates amplified carrier signals and the 3rd intermodulation signals. With attenuator A1 and phase shifter $\Phi1$, the 3rd predistorted signals are obtained. With output intermodulation signals and the 3rd predistorted signals, more than the 5th prdistortion signals are obtained. So the magnitude and phase of each predistorted signals are controlled with attenuators (A1, A2) and phase shifter ($\Phi1$, $\Phi2$).

3. EXPERIMENTS

For validation of the proposed predistortion method, the predistortion circuits and optic communication system is fabricated. The 1550nm LD of Smitomo, 1414 of New Focus for PD (Photo Detector), and 422 of New Focus for RF amplifier that connected with PD were used. In predistorter, MSA-0385 of HP is used to generate the 3rd predistortion signal, and HSMP-3822 of HP is used for HG. The diode used in the variable phase shifter is 1T362 of Sony, and the diode used in the variable attender is HSMP-4810 of HP. The operating frequencies of two-tone are 877.5MHz and 882.5MHz. Fig.5 shows the 3rd predistortion signals. Fig .6 shows more than 3rd predistortion signals. Amplitude and phase of predistortion signals are controlled by variable attenuators and variable phase shifters, respectively. Fig.7 shows the characteristic of optical communication system without prdistorter. In here, $(C/I)_{3rd}$ is 26.01dBc and $(C/I)_{5th}$ is 36.84dBc. Fig.8 shows the characteristic of optical communication system with prdistorter. With the proposed predistorter, $(C/I)_{3rd}$ is obtained 47.83dBc and $(C/I)_{5th}$ is obtained 45.3dBc. By comparing (C/I) characteristics, the practical improvement is 19.28dBc. So the increase of the linear characteristic of laser diode would expand the transmission distance of the optical communication net and improve signal in quality.

4. CONCLUSION

A new type of predistortion linearizer to reduce nonlinear distortion components of LD is proposed. The proposed predistorter controls magnitude and phase of the individual IMD component respectively. Hence intermodulation components of LD are reduced effectively. With proposed method, (C/I) increased about 19.28dBc. Maybe this method can be used in cable TV, long distance antenna system, etc.

REFERENCE

[1]Yong-Chae Jeong, *A design of predistotion liearizer controlling the Individual order of Intermodulation*, Disstation, Sogang-Univ., 1996

[2]L. S. Fock, R. S. Tucker, "Reduction of distortion in analogue modulated semiconductor lasers by feedfor-ward compensation" *Electron Letter.*, Vol .27, pp 669-671,1991
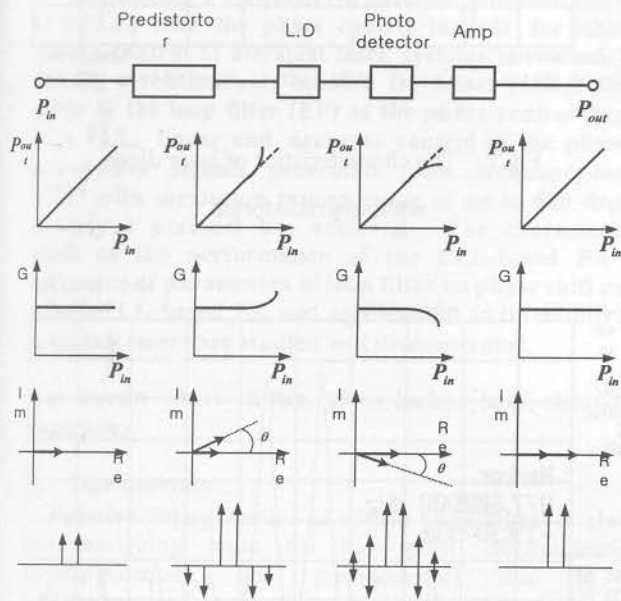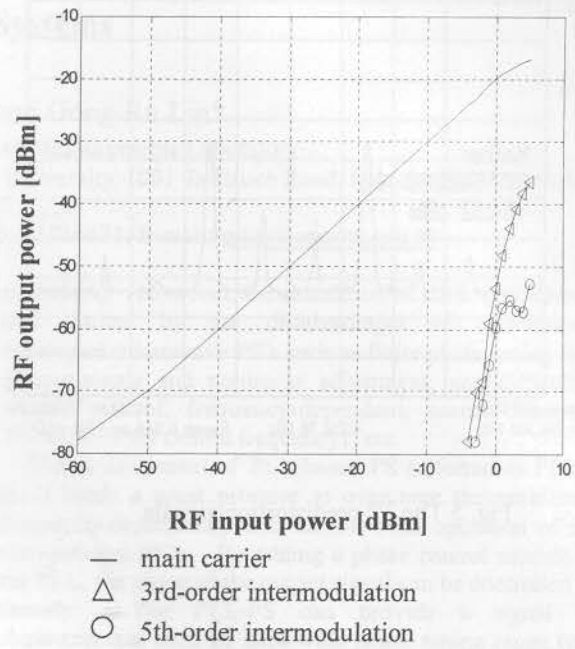
Fig 1. The operation of predistortion method

Fig 2. Nonlinear distortion characteristic of LD

RF input power [dBm]

— main carrier
△ 3rd-order intermodulation
○ 5th-order intermodulation

Fig.3 The curve of optic-current of laser diode

ALC:Auto level controller
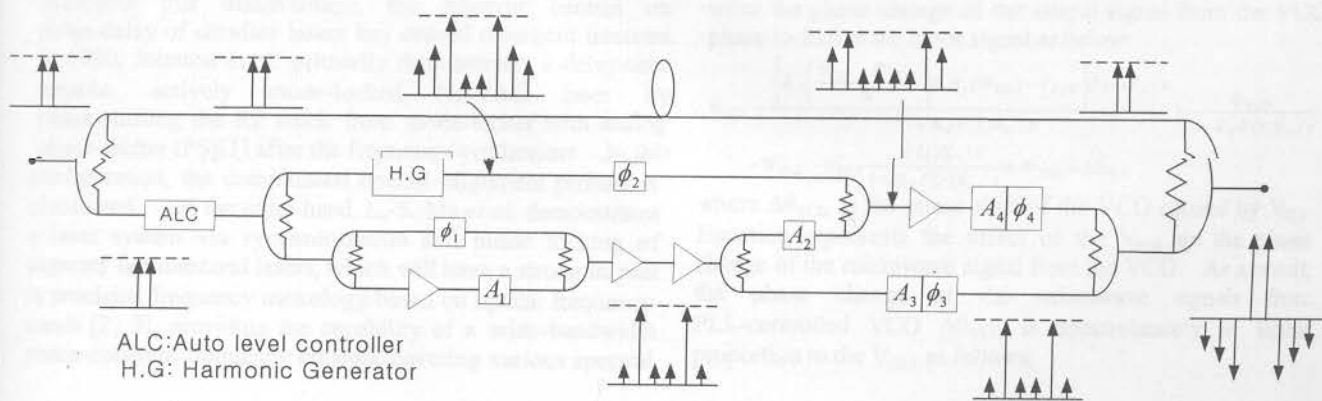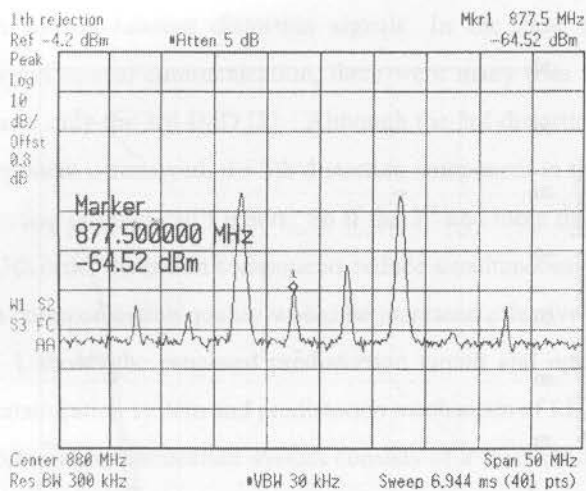H.G: Harmonic Generator
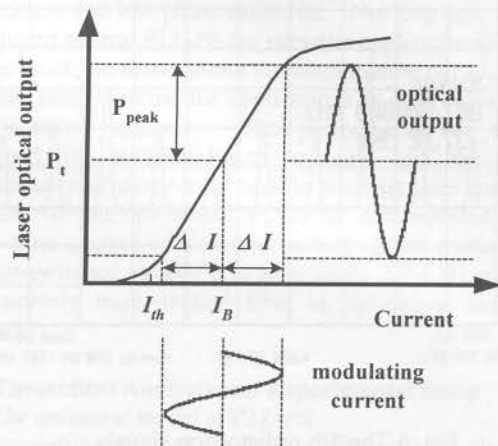
Fig .4 Block diagram

Fig. 5 The 3rd predistortion signals
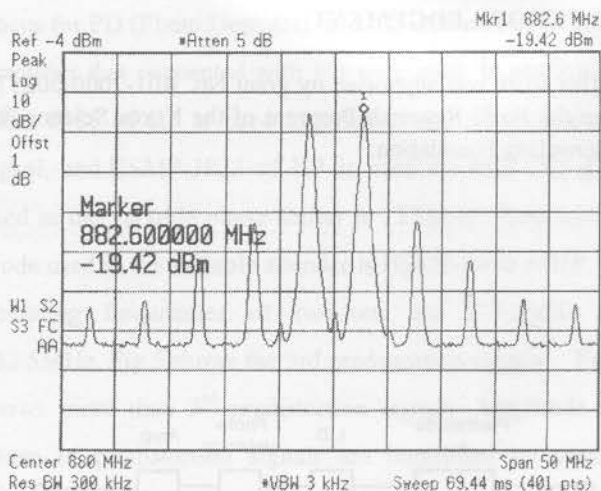
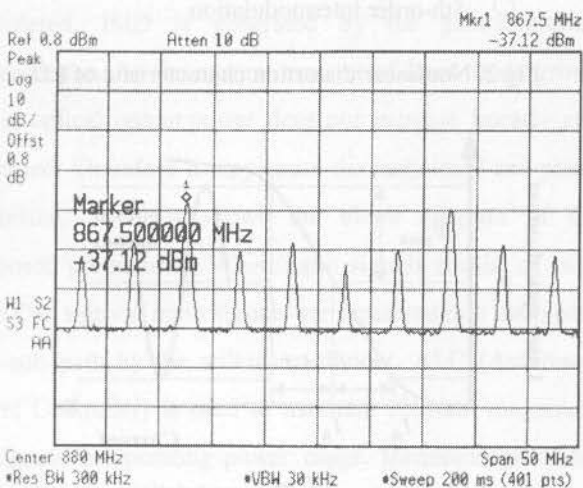Fig.7 The characteristics of laser diode
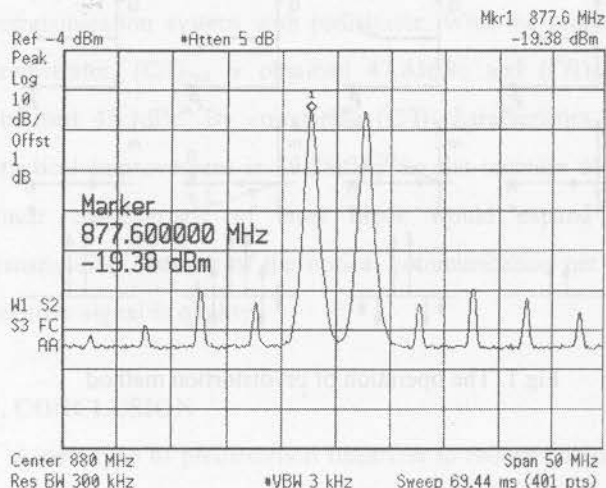without predistorter

Fig. 6 The 5th prdistortion signals

Fig.8 The characteristics of laser diode
with predistorter

Fig. 4 Block diagram.