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Optimization of Dispersion Compensation Value in Optical Fiber Transmission System

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Abstract: **We report experiments that elucidate the shift of the optimum dispersion compensation value in an optical fiber transmission system due to phase modulation in electroabsorption external modulator. As a countermeasure, we introduce the use of a lithium niobate ($LiNbO_3$) phase modulator.**

I. INTRODUCTION

Chromatic dispersion of the optical fiber is a factor that can limit the transmission distance possible in an optical fiber transmission system [1-3]. Dispersion compensation fiber with negative dispersion is generally used to offset the chromatic dispersion. However, since the external intensity modulator varies the imaginary part of the refractive index, the real part will suffer some level of modulation due to the Kramers-Kronig (K-K) relation [1]. This causes phase modulation (PM) of the optical signal passing through the optical modulator together with intensity modulation (IM). The phase modulation in the external modulator can affect the deterioration caused by the chromatic dispersion of the transmitted signal.

This paper describes the deterioration of the transmitted signal due to phase modulation in the electroabsorption modulator and introduces a countermeasure, the use of a $LiNbO_3$ phase modulator.

II. SHIFT IN OPTIMUM COMPENSATION VALUE BY PHASE MODULATION IN THE ELECTROABSORPTION MODULATOR

Figure 1 shows the experimental setup used to measure the effect of phase modulation in the electroabsorption modulator (EAM). A 1558.98 nm coherent light wave was input to an EAM. In the EAM, the light wave was modulated by a 12 GHz signal. Here, the bias voltage of the EAM was set to -2.08 V, and optical modulation index (OMI) to 40 %. The modulated light wave was passed through a single mode fiber (SMF) or dispersion compensation fiber (DCF) and detected by a photo diode. SMF yields positive dispersion (0～800 ps/nm), and DCF yields negative dispersion (0 ～ -800 ps/nm). Detected 12 GHz signal power was measured by a spectrum analyzer.

Figure 2 shows the dependency of detected 12 GHz signal power on chromatic dispersion. In the figure, the optimum dispersion compensation value shifts -200 ps/nm from 0 ps/nm. In the EAM, since the external intensity modulator varies the imaginary part of the refractive index due to the modulation signal, the real part will suffer some level of modulation according to the Kramers-Kronig (K-K) relation [1]. This causes phase modulation (PM) of the optical signal passing through that optical modulator along with intensity modulation (IM). Moreover, the intensities and phases of the optical sidebands vary due to interference by the modulation components. As a result, the optimum compensation value shifts from 0 ps/nm to -200 ps/nm.

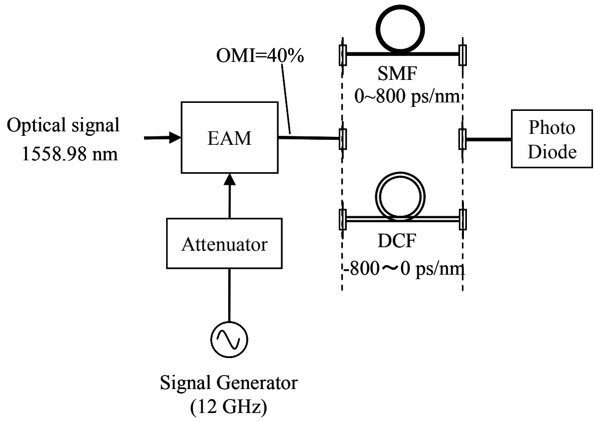

Fig.1. Experimental setup used to measure the shift in the optimum compensation value by phase modulation in the EAM. EAM is electroabsorption modulator.

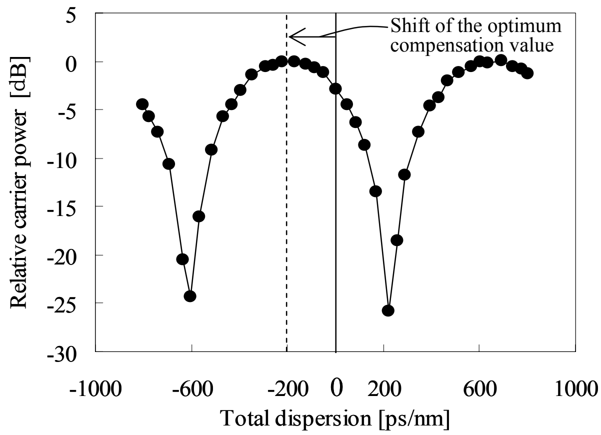

Fig.2 Detected 12 GHz signal power versus chromatic dispersion.

III. THE MODULATION SECTION TO OFFSET THE SHIFT USING $LiNbO_3$ PHASE MODULATOR

We investigate the use of the $LiNbO_3$ phase modulator to offset the shift described above. First of all, we describe about the experimental setup of the modulation section to offset the shift in the EAM.

Figure 3 shows the configuration of the proposed modulation section. In this section, the intensity-modulated optical signal from the EAM is input to a $LiNbO_3$ phase modulator. The $LiNbO_3$ phase modulator modulates the phase of the input optical signal under the control of the electrical modulation signal input to the $LiNbO_3$ phase modulator. Here, the power and the phase of this electrical signal are set by an attenuator and a phase shifter. The optical signal from the $LiNbO_3$ phase modulator is input to SMFs or DCFs shown in Fig.1 . Detected 12 GHz signal power is measured at spectrum analyzer. Wavelength of the optical signal is 1558.98 nm, bias voltage of the EAM is -2.08 V, respectively.

Next, we describe about measurement results.

Figure 4 shows dependency of the shift of the optimum compensation value on relative power of signal input to the $LiNbO_3$ modulator. As input signal power increases, the optimum compensation value shifts in a positive direction.

Figure 5 shows the shift of the complete compensation value at four values of relative phase of the signal input to the $LiNbO_3$ modulator. The horizontal axis indicates the relative phase of the signal input to the $LiNbO_3$ modulator with the signal input to the EAM. Relative input power of the signal is set to -7 dB in the Fig.4. The shift changes by 150 ps/nm when relative phase of the signal changes by π radian.

These results indicate that we can optimize the dispersion compensation value by varying the power and the phase of the signal input to the $LiNbO_3$ phase modulator.

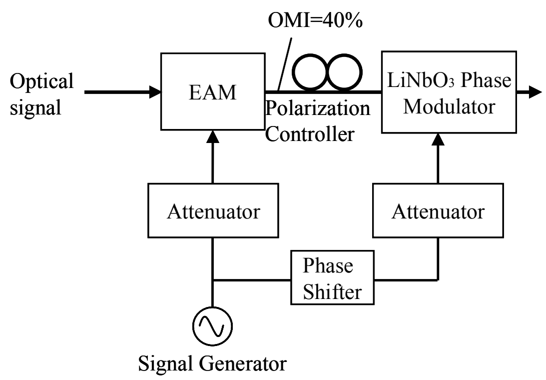

Fig.3 Configuration of the proposed modulation section.

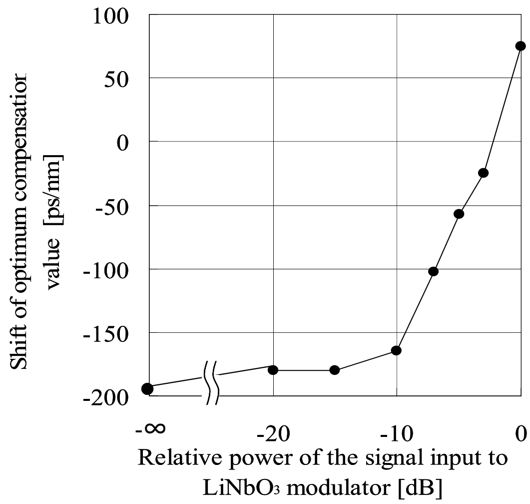

Fig.4 Shift of optimum compensation value versus relative power of signal input to the $LiNbO_3$ modulator.

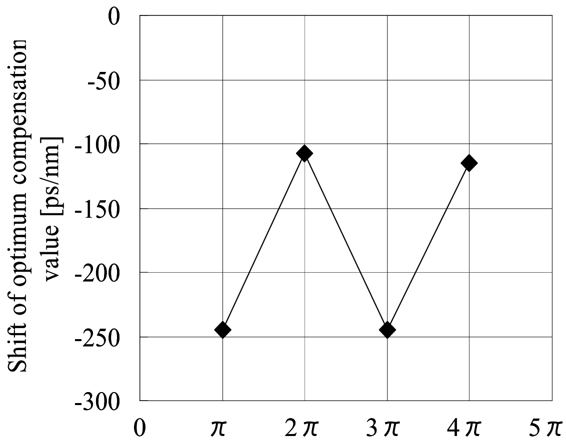

Fig.5 Shift of optimum compensation value at four values of relative phase of the signal input to the $LiNbO_3$ modulator.

IV. CONCLUSION

We clarified that the phase modulation experienced in an EAM shifts the optimum compensation value. We also showed how to optimize the dispersion compensation value with the use of a $LiNbO_3$ phase modulator.

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