TN-LCD와 λ/4 Plate를 이용한 위상 공간 광변조기의 구현

Design of Phase Spatial Light Modulator Using TN-LCD and λ/4 Plate

김 현*, 김도형, 문인규, 이연호
성균관대학교 정보통신공학부
hyuney92@skku.edu

High reliable and programmable phase spatial light modulator(P-SLM) has been studied extensively because it is needed for applications to optical image processing and optical correlator. A TN-LCD can be a good candidate for P-SLM since it is commercially available from video projector and inexpensive. Since it is suitable for amplitude modulation which is needed in display applications, many authors have studied about the possibility of TN-LCD for P-SLM. One can find the optimized angles of polarizers of P-SLM consisted of TN-LCD sandwiched between polarizers[1,2] and alternatively use the averaged polarization eigenstate of P-SLM consisted of TN-LCD sandwiched between two sets of a polarizer and a wave plate[3,4,5]. The former is simple but has usually the nonuniform intensity transmittance and the small dynamic range of a phase modualtion versus gray scale. The latter has the more uniform intensity transmittance and larger dynamic range of a phase modualtion compared with the former.

In this work we present a simple configuration of P-SLM to extend the dynamic range of a phase modulation and have the uniform intenisty transmittance compared with P-SLM consisted of TN-LCD and two polarizers. Our P-SLM consists of polarizer, TN-LCD, quarter-wave plate, and analyzer as shown in Fig. 1. When one builds a P-SLM with a TN-LCD, it is required to know the parameters of TN-LCD such as director angle at the entrance surface, twist angle, and birefringence. In this work these parameters were determined by measuring the intensity transmittances of TN-LCD sandwiched between two polarizers for different configurations of polarizers and by fitting the theoretical prediction to the data. Determined were the director angle θ_S=-5.0°, the twist angle θ_L - θ_S =-87.0°, the maximum birefringence β_{max} = 2.674rad(154°) in our TN-LCD. After characterizing a TN-LCD, we found the optimized angles of two polarizers and a quarter-wave plate that minimized the variation of the intensity transmittance of P-SLM from a computer simulation. The optimized angles of a polarizer, an analyzer, and a quarter-wave plate were found to be Ψ_P=-32°, Ψ_A=-50°, and Ψ_Q=14°, respectively.

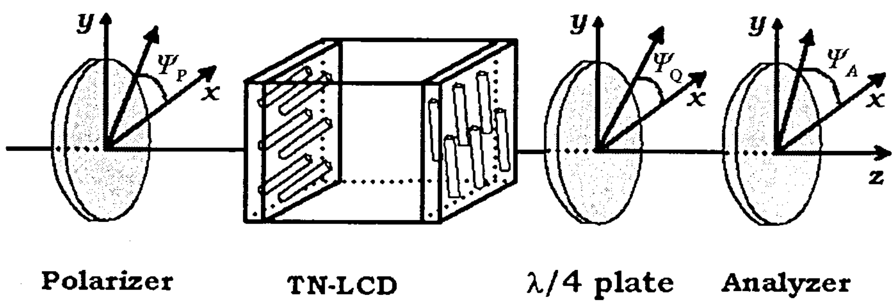

Fig. 1. Configuration of P-SLM consisted of TN-LCD, two polarizers, and quaretr-wave plate.

In our computer simulation, the optimized angles of a polarizer and an analyzer of P-SLM with no wave plate were found to be Ψ_P=-26°, Ψ_A=18°, respectively. Fig. 2 shows the normalized intensity transmittance and the phase delay predicted in this simple P-SLM system. Note that the normalized intensity transmittance has the large variation of ±20% and the phase delay has the small dynamic range less than 180°. It is shown in Fig. 3 that the normalized intensity transmittance is uniform less than ±4% and the phase delay has the large dynamic range of 280° if the optimized angles of Ψ_P=-32°, Ψ_A=-50°, and Ψ_Q=14° are used in the experiment. Note that the predicted intensity transmittance is identical for θ_S=-5.0° and θ_S=85.0° in Fig. 2 while it is different for θ_S=-5.0° and θ_S=85.0° in Fig. 3. Therefore, we could sovle the 90° ambiguity in the director angle θ_S by measuring the intensity transmittance of a P-SLM with a quarter-wave plate after TN-LCD.

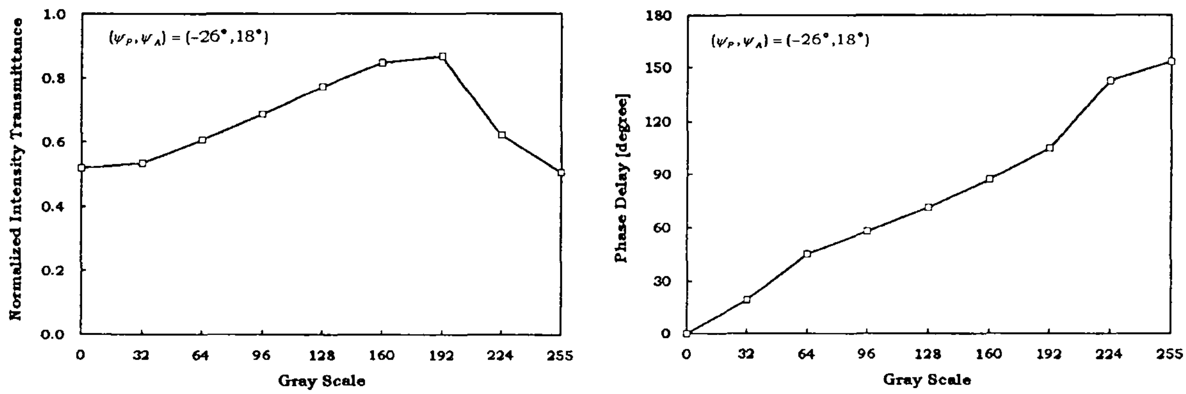

Fig. 2. Normalized intensity transmittance and phase delay of P-SLM with no wave plate. Computer simulation.

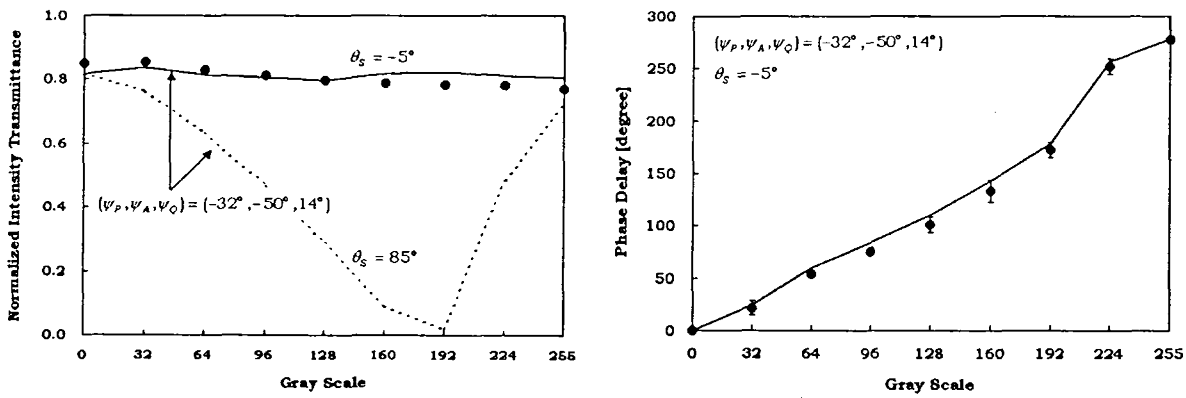

Fig. 3. Normalized intensity transmittance and phase delay of P-SLM with a quaretr-wave plate after TN-LCD. Solid and dotted lines, Computer simulation; Circles, Experiment.

References

1. N. Konforti, E. Marom, and S.-T. Wu, Opt. Lett. **13**, 251-253 (1988)
2. K. Lu and B. E. A. Saleh, Opt. Eng. **29**, 240-246 (1990)
3. J. L. Pezzaniti and R. A. Chipman, Opt. Lett. **18**, 1567-1569 (1993)
4. J. A. Davis, I. Moreno, and P. Tsai, Appl. Opt. **37**, 937-945 (1998)
5. M. Yamauchi, A. Marquez, J. A. Davis, and D. J. Franich, Opt. Comm. **181**, 1-6 (2000)