Low-Sidelobe Design of Liquid Chrystal Based Intelligent Reflecting Surface

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1. INTRODUCTION

As a typical phase control technology for Intelligent Reflecting surface (IRS), the liquid crystal-based IRS (LC-IRS) is expected for 5G communications. In this paper, we propose a method to reduce the change of the reflection magnitude by lowering the Q-value of the resonance of printed dipoles. Also a scattering pattern with low sidelobes is demonstrated by the array factor analysis.

2. DESIGN OF UNIT CELL

Figure 1 shows a photograph of the LC-IRS and the structure of the unit cell with pitch p. The design frequency is set to 47 GHz band. Model A consists of narrow-width three dipoles, Model B consists of wide-width two dipoles, respectively. Figure 2 shows the voltage characteristics of reflection phase change $\Delta\Phi$ (=ϕ (V_{LC}=V_{max})-ϕ (V_{LC} =0V)) where Vmax is the maximum voltage of Vmax=30 V, and also shows reflection magnitude change at the frequencies of 47 GHz for Model A, and 47.8 GHz for Model B. Smooth phase changes were observed for both models as the voltage increases, however, magnitude changes were totally different. In the case of Model A, the magnitude with large change from -21 dB to -6 dB was observed when voltage changes from 0 V to 10 V. On the other hand, a relatively small change of magnitude was obtained in the case of Model B. These results show that low Q-value of resonance contributes to the small change of magnitude.

3. ARRAY FACTOR ANALYSIS

Considering the scattered beam scanning with angle of θ_s=20 deg by selecting the phases of each element #1～#15 in Figure 1 from phase change chart as a function of voltages shown in Figure 2. Figure 3 shows the array factor calculated by selecting reflection phases from Figure 2. Low sidelobe level of -14 dB was obtained in case of Model B, on the other hand, high sidelobe level of -7 dB was observed in case of Model A. As shown in Figure 2, in the case of Model A, it is considered that strong magnitude variation results in non-uniform aperture distribution. On the other hand, in the case of Model B, weak magnitude variation results in almost uniform aperture distribution and low sidelobe scattering pattern has been obtained.

4. CONCLUSION

In this paper, the design of Liquid Crystal-based Intelligent Reflecting Surface at 47 GHz band has been presented having a low sidelobe scattering pattern.

ACKNOWLEDGMENT

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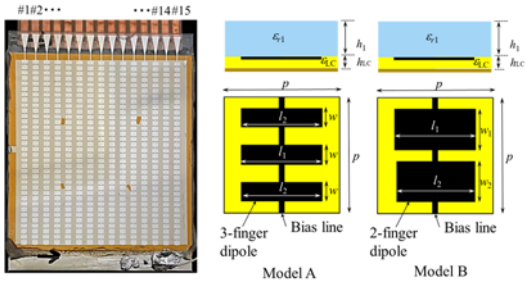

Figure 1. Photograph of Liquid Crystal-based Intelligent Reflect Surface and structure of unit cell (Model A, Model B).

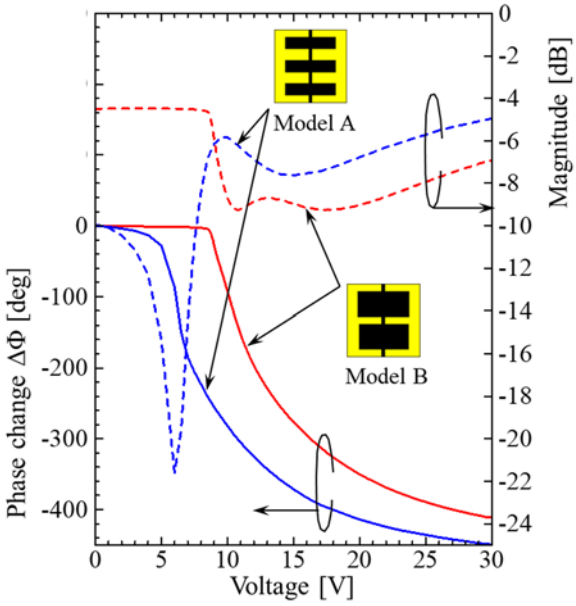

Figure 2. Voltage characteristics of reflection phase and magnitude.

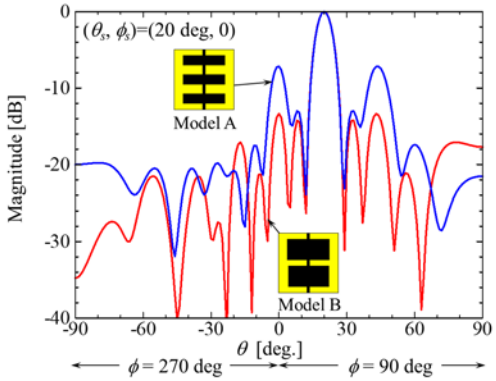

Figure 3. Array factor calculated using Figure 2.