Reconfigurable Wideband Reflectarray Design Based on Magnetoelectric Dipole Elements

Wen Wu[†1]　Qiang Chen[†1]

[†1] Department of Communications Engineering, Graduate School of Engineering, Tohoku University

1. Introduction and antenna design

A 1-bit reconfigurable magnetoelectric (ME) dipole element for broadband reflectarray is introduced. By implementing frequency-independent reflection phase of the ME dipole, both the reflection bandwidth and phase shifting stability of the 1-bit quantization unit are enhanced. Based on this design, the printed electric dipole is etched on a dielectric substrate with $\epsilon_r = 2.2$, and thickness of 3 mm, as shown in Fig.1(a). The vertical electric walls are constructed by two rows of metal through vias, which are positioned at the inner edge of each half-plane electric dipole. Thus, the magnetic dipole is formed by these five quarter-wavelength grounded vias. The GSG transmission line is made to connect the feeding via and two parallel shorted vias on either side. In order to excite the planar electric dipole and the folded magnetic dipole simultaneously, a T-shaped coupled strip is connected to the top-end of the feeding via. The ME dipole is operated as a scatterer. If the “open” and “short” switching is operated at the bottom-end of the GSG transmission line, the reflected phase can be reversed from 0° to 180° which is denoted as state 0 and state 1 in 1-bit phase quantization. The 180° phase difference is stable at a wide range because of the frequency independent character from the classical transmission line theory

2. Simulation results

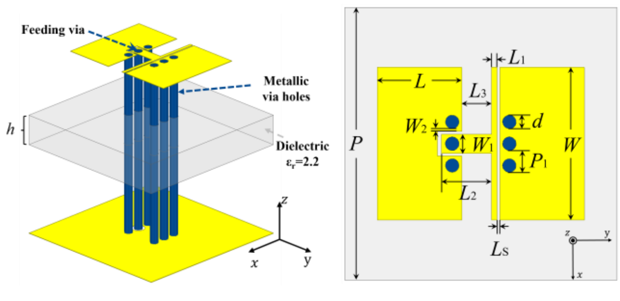
To verify the fundamental performance characteristics of this 1-bit reflectarray, static versions of the 1-bit reflectarray is investigate. The principal geometry parameters including the electric dipole arm length (L), the width of ME dipole(W), the via spacing (P_1) and unit spacing (P), as shown in in Fig.1(b), are evaluated to obtain the properly resonance frequency and bandwidth. Ansys HFSS electromagnetic (EM) solver is applied for numerical simulations for the single unit with periodic boundaries and the Floquet port excitations. The simulated reflection coefficient is shown in Fig. 2. The bandwidth of reflection phase within ±20°difference reaches up to 40%. Reflectarrays are designed for two collimated beam directions: θ =15°, φ=0° and θ=15°, φ=90° with 16 × 16 units. The 1.5 dB gain bandwidth achieves over 30%. as shown in Fig .3.

3. Conclusion

ME dipole element was deployed into wideband reconfigurable reflectarrays by means of a compact phase-shifting structure. Simulation results illustrate the great advantage in bandwidth. To the best of the authors' knowledge, the proposed design achieves the widest gain bandwidth of the reported 1-bit static or dynamic reconfigurable reflect arrays. In addition, such a wide bandwidth was realized by single-layer printed circuit board (PCB), which is very suitable for massive deployment due to its low cost.

ACKNOWLEDGMENT

This work is partly supported by the Program on Open Innovation Platform with Enterprises, Research Institute and Academia, Japan Science and Technology Agency (JST, OPERA, JPMJOP1852).



(a)　　　　(b)

Fig.1 Topology of the proposed wideband ME-dipole unit

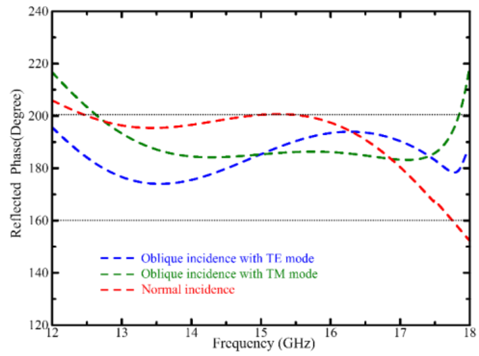


Fig.2 Reflection phase difference

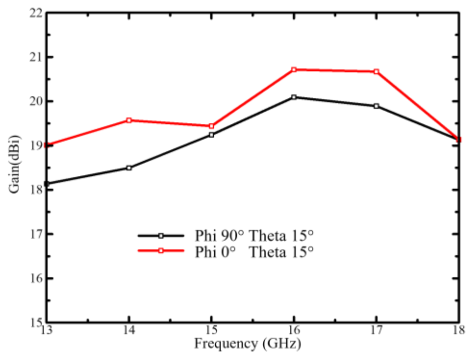


Fig.3 Gain of the proposed wideband ME-dipole unit

REFERENCES

[1] J. Huang and J. A. Encinar, *Reflectarray Antennas*. Hoboken, NJ, USA: Wiley, 2008.

[2] K. Luk and B. Wu, "The Magnetoelectric Dipole—A Wideband Antenna for Base Stations in Mobile Communications," in *Proceedings of the IEEE*, vol. 100, no. 7, pp. 2297-2307, July 2012,