Decoupling patch antenna array using magnetic metamaterials

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Abstract

In this paper, we propose a thin magnetic metamaterial (TMM) for patch antenna decoupling. Due to the strong electromagnetic (EM) waves coupling in the dielectric substrate, a TMM with negative permeability in the working frequency band of patch antenna array embedded in the dielectric substrate is designed, which can block the propagation of EM waves in the dielectric substrate and realize the decoupling of the patch antenna array. This technique can effectively decouple the patch antenna array.

Introduction

Multiple input multiple output (MIMO) technology can greatly improve the channel capacity of the system without increasing the spectrum resources and antenna transmission power, so it is very important for mobile communication. However, in the actual communication system, a large number of antennas need to be placed in a narrow space, which will produce strong coupling, affect the performance of MIMO system, and greatly reduce the channel capacity of the system. Therefore, it is very important to reduce the mutual coupling of array antenna elements.

Principle & Design

In this paper, we design a thin magnetic metamaterial (TMM) embedded in the middle of two patch antennas only 0.021λ apart. Because magnetic metamaterial can achieve negative permeability in the working frequency band of the antenna, it can block the propagation of coupled EM waves in the dielectric substrate, which greatly improves the isolation of the patch antenna array.

Simulation & iscusDsion

Then we draw the conclusion that the EM waves coupling in the dielectric substrate is more intense. If the EM waves in the dielectric substrate can be blocked, the isolation of the patch antenna array can be greatly improved. Therefore, we further studied the electric field, magnetic field and wave vector direction of EM waves in the dielectric substrate, as shown in Fig.2(c). It can be seen that the direction of magnetic field in the dielectric substrate is along the y-axis, the direction of electric field is along the x-axis, and the direction of wave vector is along the z-axis. Considering the characteristics of incident EM waves when the TMM realizes negative permeability and EM waves coupling in the dielectric substrate, we embed the TMM into the dielectric substrate vertically, as shown in Fig.3(a). In order to see the structure clearly, the dielectric substrate of the patch array antenna is hidden.

Conclusion

In a word, we design a TMM to decouple the patch antenna array with a distance of only 1mm (0.021λ) by blocking the EM waves propagation in the dielectric substrate. It can decouple the patch antenna array and improve the channel capacity. It can decouple the patch antenna array within 10% of the relative bandwidth. Moreover, the radiation pattern is basically unaffected. Therefore, this technology can effectively improve the isolation of patch array antenna.

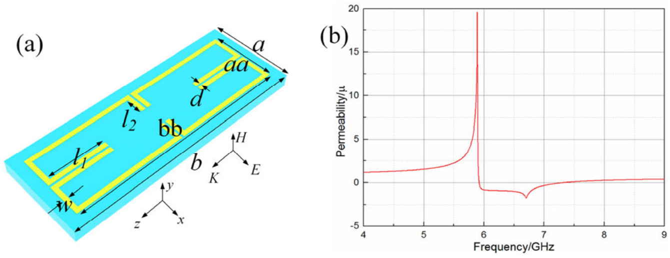

Fig.1. (a) The TMM structure;(b) The equivalent permeability of TMM

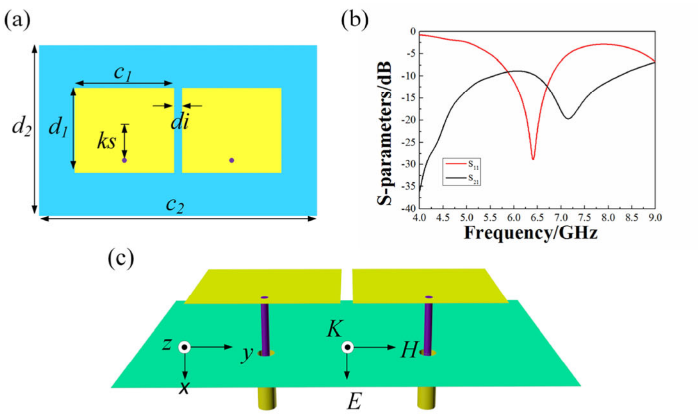

Fig.2. (a)The top view of patch antenna array;(b) The simulated S-parameters;(c) Field direction of dielectric substrate

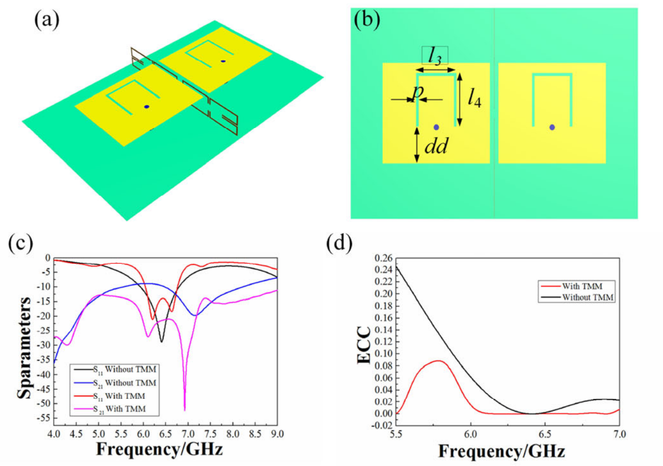

Fig.3. (a)Patch antenna array with TMM insertion;(b)The top view of the patch antenna array with TMM insertion;(c)The Sparameters of patch antenna array with TMM and without TMM;(d)The ECC of the patch antenna array with TMM and without TMM

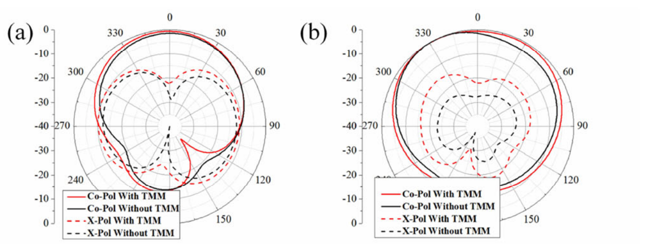

Fig.4. (a) Simulated normalized E plane radiations patterns;(b) Simulated normalized H plane radiations patterns

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