A RFID Tag Based on MIT Technology

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Abstract— In this paper, a new chipless RFID tag is designed based on the concept of metamaterials induced transparency (MIT). By inserting an arc slot on the circular loop and adjusting the length of the slot, a narrow transmission windows will appear in the stopband when the resonance frequency of circular loop is similar to the resonance frequency of arc slots. Such transmission windows has high Q factor and each transmission pole comes along two transmission zeros on its side, so the resonant frequencies can be brought very close. To make high density coding, four arc slots are added on the circular loop to generate multiple zero and pole distributions in a relatively narrow frequency band. By locating some stubs along the slot, the relevant codes are deleted because the resonators are nulled. Then four-bit chipless RFID tag is finally finished. The design concept is verified well by the full-wave simulation.

1. INTRODUCTION

Today, there is a growing demand for the application of chipless RFID tags with simple structure and high-density identification data [1–3]. In many resonant-based RFID designs, resonant frequencies can't be brought too close or they will merge into one broadband frequency response. Metamaterial induced transparency (MIT), which has a narrow transmission window in a wide absorpting band and provides an extremely large group delay, was firstly reported in Ref. [4]. It was realized by using fish-net pattern and can generate an EIT-like phenomenon. Now, the MIT-effect has attracted a lot interests in different regions [5–7].

In this paper, we propose a new chipless RFID tag design using the concept of MIT. The transmission windows in MIT has high Q factor and each transmission pole comes along two transmission zeros on its side, so the resonant frequencies can be brought very close thus achieve high density data coding. By inserting an arc slot on the circular loop and adjusting the length of the slot, a narrow passband will appear in the stopband when the resonance frequency of circular loop is similar to the resonance frequency of arc slots. Four-bit chipless RFID tag is detailed designed and verified well by the full-wave simulation.

2. MIT REALIZED BY ARC SLOT ETCHED ON RING RESONATOR

In this section, we first analyze the characteristics of our novel MIT structures. Single circular loop structure is first presented in Fig. 1(a), where periodic boundary condition is set all around the structure and floquet port is used for inputting and outputting the signal. From the simulated S_{21}

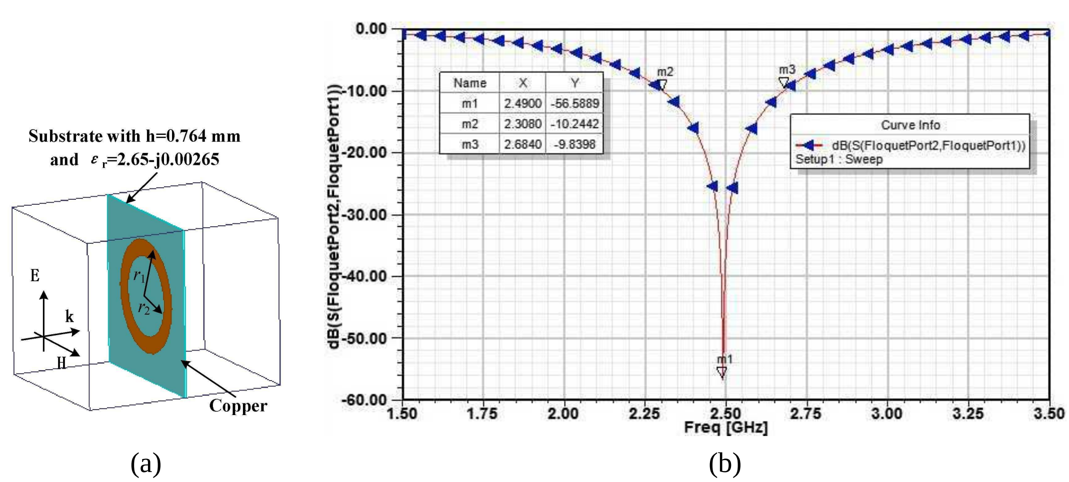

Figure 1: Schematic structure and resonant response of a circular loop with $r_1 = 27\,\text{mm}$ and $r_1 = 19.2\,\text{mm}$. (a) Schematic Structure. (b) Simulated S_{21}.

results in Fig. 1(b), we notice that, a $-10\,\mathrm{dB}$ stop band is obtained from 2.306 GHz to 2.683 GHz with relative bandwidth of 15.11%.

In order to realize a MIT effect, an arc slot is then added as shown in Fig. 2(a). Changing the length of arc slot (referred to different angles), the transmission window is varied. Fig. 2(b) gives the simulated results of two examples where two angles of $\theta = 50°$ and $60°$ is chosen, two transmission windows with center frequency of 2.206 GHz and 2.608 GHz are obtained, respectively. This means that when more arc slots are etched on the circular loop, more transmission windows

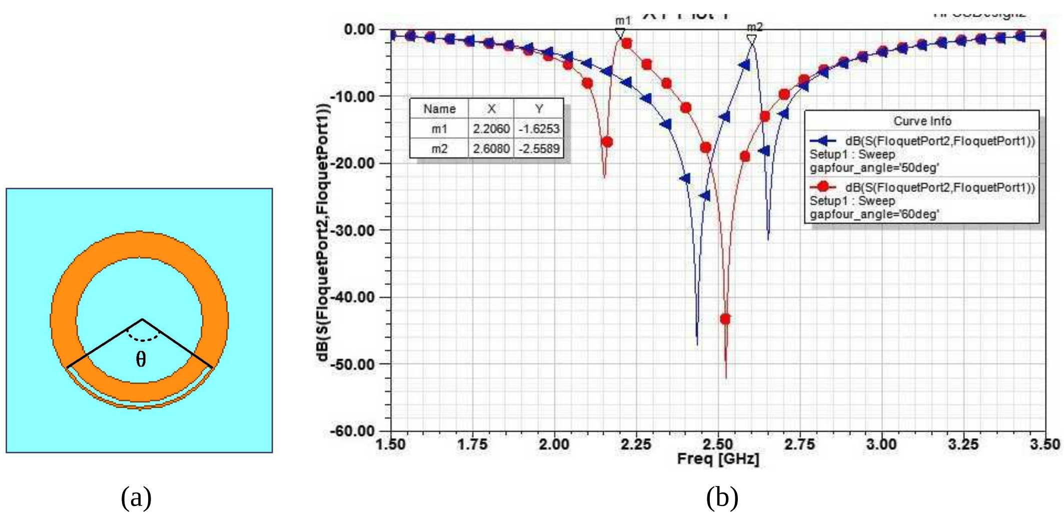

Figure 2: Schematic structures and transmission responses of EIT structures with $\theta = 50°$ and $\theta = 60°$, respectively. (a) Schematic Structure. (b) Simulated S_{21}.

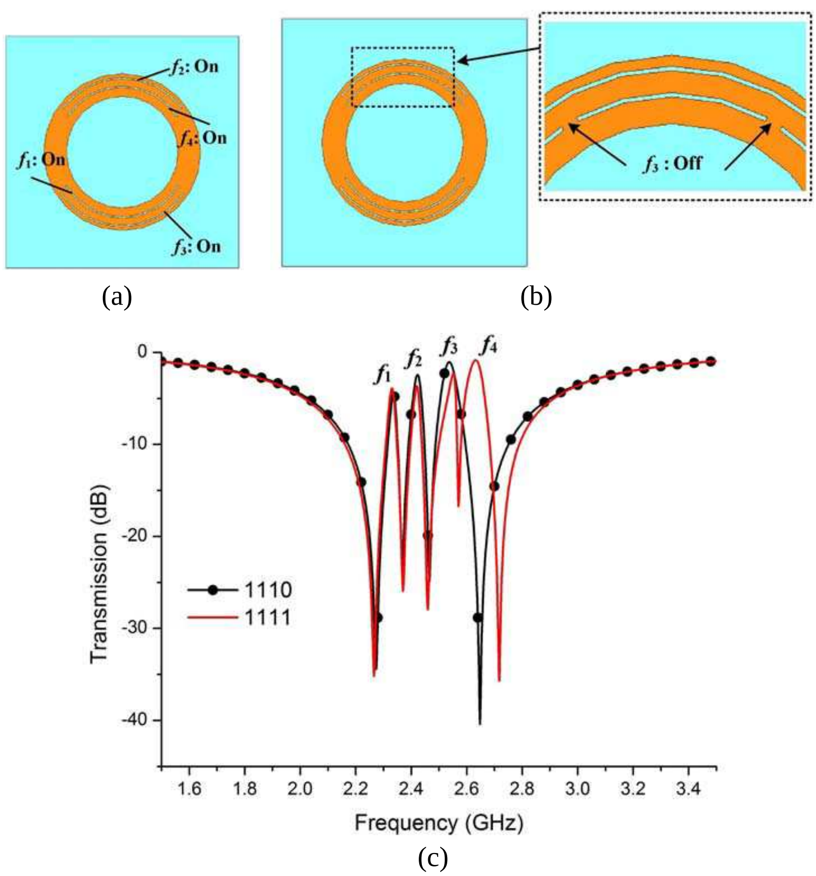

Figure 3: Chipless RFID based on MIT-effect. (a) Structure of 1111-code. (b) Structure of 1110-code. (c) Transmission responses of two codes.

are hoped to be achieved.

3. CHIPLESS RFID TAG DESIGN

In this section, we would like to use the proposed MIT structure to design a chipless RFID tag. As a sample, we add four arc slots on the circular loop as shown in Fig. 3(a). Two slots are etched on the top part of the loop and resonant at the center frequencies of f_1 and f_3, respectively. The other two slots are etched on the bottom part of the loop and resonant at the center frequencies of f_2 and f_4, respectively. In order to form different codes, two stubs are suggested to add to the slot as shown in Fig. 3(b). We can image that when the stub is added, the relative transmission windows will be closed.

In order to verify our design concept, two situations are detailed designed with their responses in Fig. 3(c). From Fig. 3(c), we notice that when four slots are presented at the same time, four transmission windows are presented with each center frequency of 2.332 GHz, 2.424 GHz, 2.552 GHz and 2.632 GHz. This situation is marked as the code of 1111. When we add two stubs to the inner slot on the top part. The transmission window of 2.632 GHz is disappeared which refers to the code of 1110. Only 0.3 GHz-band is occupied by four-bit coding which is narrower than many other published results. If wanted, more situations can be achieved just by adding or deleting the stub to or from relative slots.

4. CONCLUSION

we propose a new chipless RFID tag designed using the concept of MIT. The MIT structure is discussed in detail. By inserting an arc slot on the circular loop and adjusting the length of the slot, a narrow transmission window appears in the stopband when the resonance frequency of circular loop is similar to the resonance frequency of arc slots. Each transmission pole comes along two transmission zeros on its sides, so the resonant frequencies can be brought very close thus achieve high density data coding in our RFID tag design. Four-bit chipless RFID tag is finally proposed, and only 0.3 GHz-band is occupied which is narrower than many other published results. If wanted, more bit codes can be further achieved by adding more arc slots in one circular loop. Such RFID tag is easy to be designed and can be used in many real regions.

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REFERENCES

1. Preradovic, S. and N. C. Karmakar, "Chipless RFID: Bar code of the future," *IEEE Microwave Magazine*, Vol. 11, No. 7, 87–97, 2010.
2. Vena, A., E. Perret, and S. Tedjni, "A depolarizing chipless RFID tag for robust detection and its FCC compliant UWB Reading system," *IEEE Microwave Magazine*, Vol. 61, No. 8, 2982–2994, 2013.
3. Karimi, G. and S. Majidifar, "A novel chipless RFID tag using spiral resonator to achieve the pentamerous data encoding form," *Journal of Electromagnetic Waves and Applications*, Vol. 28, No. 1, 13–27, 2014.
4. Papasimakis, N., V. A. Fedotov, and N. I. Zheludev, "Metamaterial analog of electromagnetically induced transparency," *Physical Review Letters*, Vol. 101, No. 25, 2593, 2008.
5. Tassin, P., L. Zhang, T. Koschny, et al., "Planar designs for electromagnetically induced transparency in metamaterials," *Optics Express*, Vol. 17, No. 7, 5595–5605, 2009.
6. Meng, F. Y., Q. Wu, D. Erni, et al., "Polarization-independent metamaterial analog of electromagnetically induced transparency for a refractive-index-based sensor," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 60, No. 10, 3013–3022, 2012.
7. Park, J. W., P. Van-Tuong, J. Y. Rhee, et al., "Multi-band metamaterial absorber based on the arrangement of donut-type resonators," *Optics Express*, Vol. 21, No. 8, 9691–9702, 2013.