# An Analysis on the Compact Quasi-Isotropic Antenna Using Folded Split Ring Resonator

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***Abstract*—This paper describes an analytical study on the folded split-ring resonator (FSRR) to verify its operation. The electric and magnetic dipole moment of the FSRR is first calculated and the folded dipole analysis is then applied to the FSRR. The results of the calculation and the simulation show good agreement.**

***Keywords— Electrically small antennas, electric dipole, mangetic dipole, split ring resonator, quasi-isotropic antennas***

## I. INTRODUCTION

Nowadays, split-ring resonators (SRRs) have been widely used for the design of microwave components due to its compact electrical size [1]. The SRR has also been used for the small antenna designs, however, the feeding structure are complex or bulky due to poor radiation resistance of the SRR. In [2], the folded split-ring resonator (FSRR) is proposed to handle the radiation performances of the SRR with simple direct feeding. In this paper, the operation of the FSRR is verified analytically.

## II. ANALYTICAL STUDY

The configuration of the FSRR, which consist of two SRRs connected at the end, is shown in Fig. 1. Since the SRR can be considered as dipole in circular shape, the current distribution is assumed as

$$\boldsymbol{I}(\varphi) = I_0 \cos(\varphi/2 + \pi/4) \qquad (1)$$

As the current distribution is given, the electric and magnetic dipole moment can be calculated which are the sources of the Maxwell's equations, respectively. The calculated radiation resistance is

$$R_{rad,\,SRR} = (32/3)\,\pi^3 Z_0 (r_0/\lambda)^4 + (32/27)\,\pi Z_0 (r_0/\lambda)^2 \qquad (2)$$

The folded dipole analysis, which are even and odd mode, is then applied to the SRR to analyze the FSRR structure. Fig. 2 describes the equivalent circuit model of the FSRR and the input impedance result. It agrees well with the simulation. The input impedance of the FSRR at the resonance is four times of the SRR implying that the radiation characteristics of the FSRR can be improved than SRR providing impedance matching and higher radiation resistance so that the simple coaxial feeding is possible. In addition, the radiation pattern of the FSRR would be quasi-isotropic as it can excite electric dipole moment and magnetic dipole moment simultaneously.

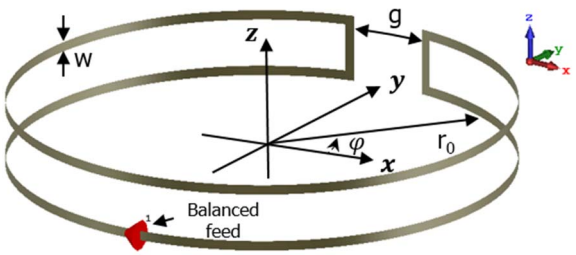


**Fig. 1** The configuration of the folded split ring resonator

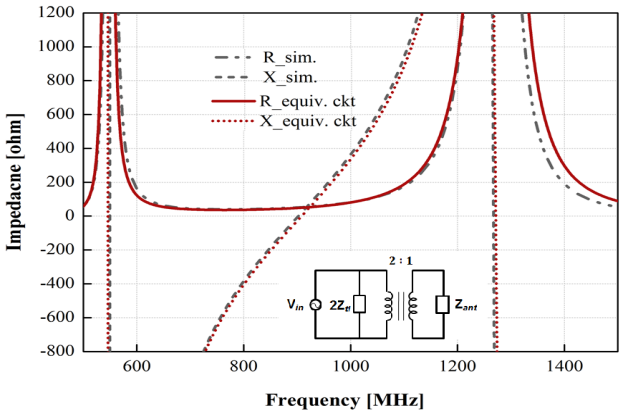


**Fig. 2** The input impedance of the equivalent circuit and simulation

## III. CONCLUSION

The operation of the FSRR is analyzed by calculating the dipole moments and applying folded dipole analysis. The calculated and simulated results are well matched. The radiation properties of the FSRR can be further improved using asymmetric FSRR that the width of each SRR are different.

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